HAWAII AGRICULTURAL EXPERIMENT STATION

E. V. WILCOX, SPECIAL AGENT IN CHARGE.

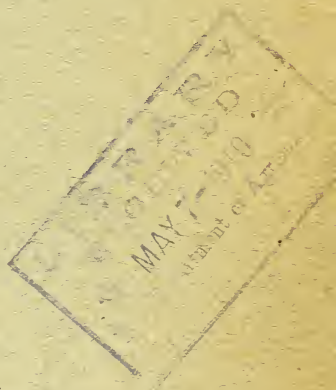
ANNUAL REPORT

OF THE

HAWAII AGRICULTURAL EXPERIMENT STATION

FOR

1909



UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS.

U. S. DEPARTMENT OF AGRICULTURE.

HONOLULU:
PARADISE OF THE PACIFIC PRESS
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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

Walter H. Evans, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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E. V. Wilcox, *Special Agent in Charge.*
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V. S. Holt, *Assistant in Horticulture.*

LETTER OF TRANSMITTAL

HAWAII AGRICULTURAL EXPERIMENT STATION,
HONOLULU, HAWAII, Feb. 16, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Hawaii Agricultural Experiment Station for the fiscal year 1909.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

DR. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON, *Secretary of Agriculture.*

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ANNUAL REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION FOR 1909

SUMMARY OF INVESTIGATIONS

By E. V. Wilcox, *Special Agent in Charge.*

DIVERSIFIED AGRICULTURE.

During the past year gratifying success has been had in developing a substantial interest in the diversification of agriculture in the Territory. The apparent hesitation which has frequently been shown by citizens of the Territory in engaging in general lines of agriculture has evidently been due not to any doubt as to the possibility of raising a great variety of crops, but to a lack of specific experimental data as to where the best seed may be obtained, the best cultural methods for these crops, and facilities for marketing them. All of our citizens, who are most actively interested in the development of the Territory, have gladly welcomed any information or experimental data which may serve to establish, on a business foundation, any line of agricultural industry which promises commercial success. This statement is fully justified by the active interest shown in the pineapple industry, the development of rubber plantations, the rapid spread of cotton planting, the cooperation of land owners and growers in making the rice crop more profitable, and in the general activity in increasing the acreage of forage crops, garden crops, and miscellaneous fruits and crops.

The area planted to corn is being rapidly enlarged and satisfactory returns are everywhere being reported. From large areas average yields of forty bushels per acre of corn have been obtained under rainfall conditions varying from 5 to 240 inches per year, and at altitudes ranging from sea-level to 5,000 feet.

The acreage of alfalfa, sorghum, Rhodes grass, Para grass, cowpeas, jack beans, soy beans, and other forage crops is increasing at a corresponding rate.

Not only are these crops, which are regarded as the mainstay of agriculture in temperate climates, considered as worth while in themselves, but their importance in systems of rotation is being recognized, and this means that the further extension of the area devoted to miscellaneous crops will proceed more rapidly in the future than in the past.

The definite policy has been adopted of making the chief work of the members of the staff that of investigation, in order that actual contributions may be made to the sum total of agricultural science. Naturally, however, some attention must be given from time to time to miscellaneous requests for practical information from farmers. An attempt is made, however, to prevent this work from interfering too greatly with the regular lines of investigation.

CHEMICAL INVESTIGATIONS.

The chemist and assistant chemist have confined their attention during the year almost exclusively to the study of pineapple soils, research on the fertilization and nutrition of rice, and fertilizer experiments with cotton. A preliminary report on the relation of manganese to the growth of pineapples has already been published in Press Bulletin 23. It appears, from further study of pineapples, that this plant is exceedingly sensitive to soil conditions, and does not thrive satisfactorily when planted continuously on the same soil. The poor results from a one-crop system are not yet definitely explained, but are partly due to the depletion of the organic matter in the soil from this system, and the consequent packing of the lower layers of the soil. When it is remembered that these soils contain unusually large amounts of ferric hydrate, which acts very much like clay, it is easily understood that with a heavy rainfall the soil becomes saturated with water and cannot be properly aerated by superficial cultivation.

The fertilizer experiments with pineapples are not yet completed for the reason that eighteen months are required from the time of planting until the first harvest. At present, however, the growth of the plants indicates clearly that certain combinations of fertilizers are very effective, while others are prac-

tically without result. The scientific explanation of these results, and practical conclusions to be drawn from them, must be postponed until the experiment is completed.

Plans have been made for putting in two drainage experiments. There is abundant evidence that some of the poor results obtained from pineapples, in restricted areas, are due to lack of drainage. No tile drainage has hitherto been used in the islands, and it is believed to be worth while to test its efficiency under our conditions.

A considerable number of soil samples have been analyzed in order to secure data on the distribution of manganese in the pineapple fields. As indicated in the preliminary report, already referred to, black soils contain relatively high percentages of manganese and such soils have proved unsuitable for pineapple culture. It has been found that the manganese in this soil is exceedingly soluble; that in the growth of pineapples it undergoes a higher oxidation, and that this change is detrimental to plant growth. It is hoped that during the present year we may find a scientific explanation of the effect of manganese upon pineapple plants and upon the plant nutrients in the soil.

An important experiment has been undertaken with rice to determine the period of growth in which various nutrients are absorbed and their inter-relations with reference to the development of the plant. One series of cultures has already been completed, and analyses of various parts of the rice plant, at different stages of growth, are being made. The experiment will be repeated on another crop of rice in order to obtain further evidence on some of the data which have already appeared. It has been found that certain fertilizer materials affect the composition of rice as regards its nitrogen content.

The results thus far obtained from a fertilizer experiment on cotton indicate that the growth of the plants has been greatly increased by the use of phosphates.

COTTON INVESTIGATIONS.

Since the spring of 1908 considerable attention has been given to the investigation of the culture and breeding of cotton. In the experimental plats we have about 30 varieties of cotton, including Sea Island, Caravonica, Egyptian, Chinese, upland, and native cottons.

It has been found that all varieties of cotton grow here as perennials. In order to maintain a suitable form in the plants, it is desirable to pinch back the terminal buds or prune the plants. The removal of the old wood and trash helps in controlling insect troubles and makes it possible to throw the fruiting season at the desired time of the year. The operation of pruning is simple and not excessively time-consuming and can be recommended for commercial practice.

In obtaining pure strains of cotton, free from the effects of crossing, resort has been had to the use of cuttings. This has been found to be a very satisfactory way for propagating pure strains, and will be used more extensively in the future. Following upon the success had by one of the cotton growers of the Territory, a number of experiments in budding cotton have been made with satisfactory results. It seems to be no more difficult with cotton than with other plants which are commonly treated in this way.

The area planted to cotton during the past year was about 100 acres, but arrangements have already been made for planting somewhat more than a thousand acres during the coming year. All of the commercial ventures in planting cotton, thus far undertaken, have proved very encouraging. The climatic conditions, while exceedingly variable in different parts of the islands, are nearly all favorable to the growth of cotton up to at least an altitude of 800 feet, and within a range of rainfall of 20 to 100 inches.

ENTOMOLOGICAL INVESTIGATIONS.

The attention of the entomologist has been chiefly devoted to a study of cotton insects and plant lice. A bulletin on cotton insects has recently been published.[1] Leaf-eating caterpillars have been unusually injurious during the year and have made it necessary to devote some attention to these pests. Cutworms and army worms have attacked a great variety of crops, including rice and alfalfa, causing a good deal of damage, but fairly satisfactory methods of controlling these pests have been applied.

Arrangements have been made for introducing parasites of algaroba weevils, plant lice, and scale insects. The Bureau

[1] Hawaii Sta. Bul. 18.

of Entomology has already begun shipments of parasites and lady-birds for this purpose. In addition to this means of control, the Florida Experiment Station has undertaken to furnish us with cultures of parasitic fungi to aid us in keeping down scale insects and plant lice.

On account of the great prevalence of plant lice upon all sorts of cultivated and wild plants, particularly during the winter season, it has been thought desirable to make a special study of these pests. The entomologist has devoted much time to this problem. A fairly complete collection of the plant lice of the Territory has been made, and from a careful study of this collection, in connection with all available literature on the subject a synopsis of the Aphidae has been prepared in which all of the important species known to occur in Hawaii are described and details are given for their ready indentification. In this work a few new species were found and have been described.

HORTICULTURAL INVESTIGATIONS.

Much time has been given to methods of propagating citrus fruits and mangoes. The growers of these fruits have experienced considerable difficulty in successfully budding them. It appears that satisfactory results are to be obtained by adopting the ordinary method of budding citrus fruit, with an inverted "T". The lack of success in budding citrus fruit may be due to infertility of the soil, insufficient moisture, lack of vigor of the trees, and insects and fungus diseases. Attention must, therefore, be given to all of these points in order to get the best results. In this work it was found neccessary to give some attention to scale insects, aphids, cut-worms and other pests which may interfere with the success of budding. The use of kerosene emulsion was found unsatisfactory and too expensive, but far better results were obtained by fumigation. In budding mangoes the best results have been obtained from the application of the "shield" method with the inverted "T", using only well-matured wood and cutting the "T" and the "shield" very long, the former six or seven inches, and the latter, three or four inches. Gratifying success has also been obtained from inarch-in the case of the mango. A series of experiments is now under way in developing a more practical method for budding the avocado. It is certain that the production of commercial quant-

ities of fine mangoes and avocados depends primarily on practical methods of budding orchards devoted to these fruits.

An elaborate system of keeping laboratory and field records for the purpose of locating trees and plants upon which experiments are made, has been devised and will tend to render the keeping of records more convenient and satisfactory.

The use of cover crops in orchards during the winter appears to be quite necessary on slopes where excessive washing of the soil would otherwise occur. For this purpose, cowpeas and jack beans have given the best results. A series of experiments with a considerable variety of garden vegetables is in progress, but the results are not yet available.

On account of numerous requests from the mainland for dried roselle, an experiment was made in drying this fruit. It was found that the dried material could not be produced profitably at the price which the mainland dealers offered for it. Our experiments indicate that 12.8 pounds of the fresh fruit are required to produce one pound of dry calyces. It would appear more profitable, therefore, to use this fruit in a fresh state for the production of jams and jellies.

RICE INVESTIGATIONS.

In a fertilizer experiment with rice it was found that 200 pounds per acre of a complete fertilizer gave practically as large yields of paddy as did greater quantities up to 800 pounds. Moreover, the results were approximately the same whether applied before the crop was planted, or when well advanced in growth. A number of cooperative fertilizer tests were made for the purpose of testing, on a commercial scale, the results already obtained on the trial grounds, and to bring greater profits, if possible, from the rice industry. These experiments were entirely satisfactory, in so far as the results from the fertilizers were concerned, but were somewhat interfered with by the unusual insect troubles to which rice was subjected during the past year. The variety of rice, referred to in previous reports as No. 19, is now firmly established and has given excellent returns wherever it has been planted. Satisfactory progress is also being made with upland rice as a hay crop.

RUBBER INVESTIGATIONS.

During the past year tapping experiments were carried out on more than 400 rubber trees for the purpose of determining the yield which may be expected from rubber, the best methods of tapping, the possibility of economically using Japanese labor for this purpose, the time of day at which tapping should be made, the effects of tapping upon rubber trees, methods of coagulating latex, and the stimulating effect of fertilizers upon the flow of latex. These experiments indicate that the Ceara rubber tree in Hawaii may be planted on a commercial scale with the assurance of reasonable profit. A bulletin, covering these investigations, is now in press.

MISCELLANEOUS INVESTIGATIONS.

During the past year some attention was given to methods of grinding algaroba pods. These constitute one of the most important forage products of Hawaii, but on account of the indigestibility of the seeds, without grinding, a large part of the protein content of the pods was lost. A number of farmers had attempted to grind the pods, but had failed on account of their sticky nature. It was found, by laboratory experiments, that by slightly moistening the cracked pods and then drying them, they could be readily ground with any form of feed mill. The importance of a special mill for grinding algaroba pods in a fresh condition, was suggested to a local inventor and machinist, who has since perfected a machine which grinds the pods in a satisfactory manner. In devising this machine, the inventor adopted some of the ideas already developed in our work and cooperated with the station to the fullest extent. The use of these machines will undoubtedly become quite general and will add greatly to the available nutritive value of the algaroba.

In the perpetual conflict with weeds it is necessary to use every possible means which is efficient in destroying them. For this reason an experiment was made in destroying various weeds by means of carbon bisulphid. It was found that herbaceous as well as shrubby weeds could readily be destroyed by this chemical. A tablespoonful of carbon bisulphid, poured upon the stem, about six inches above the ground, will cause the death of such weeds as Oi, Crotalaria, prickly pear, lantana, and

guava within a period ranging from twenty-four hours to six weeks or two months. A press bulletin on this subject has recently been published.[1]

The federal funds, available for the use of this station, were supplemented at the last session of the territorial legislature by an appropriation of $10,000 for the biennial period, and an additional sum, to be allotted by a commission, from the surplus revenues of the Income Tax. This generous appropriation by the Territory will make it possible for the station to extend its work in various directions, particularly in the study of plant diseases, forage crops, and suitable rotations. Along this line, there is already in progress, or in contemplation, rotation or intercultural experiments with rubber, pineapples, cotton, rice, taro, etc.

1 Hawaii Sta. Press Bul. 25.

REPORT OF THE ENTOMOLOGIST

By David T. Fullaway.

GENERAL INSECT NOTES.

The year has been very interesting from an entomological standpoint in showing some long-known pests in new roles and in broadening the knowledge of our insect fauna. At the beginning of the year some attention was given to the means of combating pineapple pests, in order, primarily, to reduce the losses occasioned by these pests, but more particularly to check their spread, and this work was followed up in the spring. Dipping and fumigating suckers and the liberal application of tobacco dust to the plants kept both mealy-bug (*Pseudococcus bromeliae?*) and the scale-bug (*Diaspis bromeliae*) at a minimum. It would be well if the growers would adopt a uniform method in attempting to control these two pests.

Aside from work of a purely investigational character, numerous inquiries in regard to insect pests of agricultural crops and means of combating them have been answered by correspondence. In some instances personal inspection of the conditions was made and advice offered. The station's collection of economic insects has been maintained and much material added.

In January, 1909 the entomologist, Mr. D. L. Van Dine, secured leave of absence to visit the mainland of the United States, and on March 1st presented his resignation in order to accept a position with the United States Bureau of Entomology in the southern field crop insect and tick investigations at Dallas, Texas. The writer, who was appointed assistant entomologist at the station on August 17th, succeeded Mr. Van Dine as entomologist.

The chief investigation of the year has been of the insects affecting the cotton plant in Hawaii, the results of which are contained in Bulletin 18. This work was necessitated by the increasing interest in the possibilities of cotton growing, following the station's cultural experiments extending over three years. The cotton bollweevil (*Anthonomus grandis*), the most destruc-

tive of the insect enemies of cotton in the United States, is not found in Hawaii, and the cotton bollworm (*Heliothis obsoleta*), while here, is so heavily parasitized that it is not likely to become an important factor in cotton production. The most destructive cotton pest is probably an Indian introduction, the larva of a Tineid moth, *Gelechia gossypiella*. This bollworm in India, according to Lefroy, may cause an annual loss of $4,000,000. Here, from 5% to 50% of the crop is damaged by the worm, which attacks and destroys the young ovules, preventing the formation of bolls, or more frequently enters maturing fruit, soiling the lint and causing premature opening and rotting. The worm is attacked by a Braconid parasite (*Chelonus blackburni,*) which is more or less effective in reducing its numbers. Other pests of a more or less serious nature were found. Seedling plants are attacked by wireworms and cutworms, commonly injurious to nearly all agricultural crops. A greenfly (*Aphis gossypii*) intermittently attacks the plants and at times is very destructive. It is controlled by spraying and by predaceous enemies (Coccinellids), of which there are many introduced species. The Japanese beetle (*Adoretus tenuimaculatus*) at times attacks the foliage but does not appear to be a serious pest. Two virulent Coccid species, *Pseudococcus virgatus* and *P. filamentosus,* are at times pests of cotton and greatly injure the plants. They are being constantly held in check by predaceous enemies (Coccinellids), but can nearly always be found in the cotton field doing considerable damage. There are many minor pests, the injury from which is more or less negligible, as *Archips postvittanus* and *Amorbia emigratella,* Tortricid moths whose larvae fold the leaves, a species of Thrips injuring the buds, and a species of Tetranychus (red spider) on the foliage. The employment of artificial remedies has been advised in some cases, but on the whole, or on a large scale, is considered impractical. As stated, many insects are kept in check and their injuries greatly lightened by natural enemies. The introduction of other parasites and predators is recommended, as it is believed that much may be hoped from them.

The winter and spring were marked by excessive outbreaks of cutworms. Three species were especially bad, *Agrotis upsilon, Heliophila unipuncta,* and *Spodoptera mauritia.* For the first time in the history of rice cultivation in the islands this cereal was attacked by *H. unipuncta.* From all the rice-

producing sections of the islands the reports indicated serious losses due to the ravages of *H. unipuncta* larvæ. Early fruiting and late maturing crops escaped, but the bulk of the rice, maturing in the latter part of May, was very badly affected. In the early part of June the entomologist visited most of the rice fields on Oahu, and while some seemed to have suffered less than others, the presence of the worm, to some extent, was established in all. At two places on Kauai, and at Kalihi, Punaluu, Haula, and Kailua on Oahu, the damage was very severe, amounting to from 10% to 60% of the crop.

Another insect of economic importance, a Tortricid moth close to *Archips* [1] (there are undoubtedly several species involved, one being *A. postvittanus,* which, however, is parasitized in the egg-stage), is increasing enormously and gives promise of being a serious pest of fruit. It attacks a great variety of soft and succulent fruits—citrus, alligator pear, guava, passion flower vine, tomato, and still others. Of these, only the citrus, alligator pear, and tomato are fruits cultivated for the market, and none is grown in a large way. If citrus culture is undertaken on an extensive scale, this pest must be taken into account, as along with other enemies of citrus fruits, the damage to the crop will be very heavy. Spraying with arsenate of lead was recommended and used with effect.

Some attention was given to beekeeping, and it was proposed to investigate the possibility of increasing the production of wax by new methods of manipulation. Suitable arrangements for this work have not yet been made.

The introduction of parasites of the beanweevils, of which several species are serious pests, attacking the pods of *Prosopis juliflora* and other leguminous plants which are used chiefly as animal fodders, has been undertaken and from the two or three shipments of parasites already received a large Braconid (*Heterospilus* sp.) has been bred in numbers and liberated. Other shipments of parasites are expected and much is hoped from them. These parasites were received from Texas, through the cooperation of the United States Bureau of Entomology, and the station is especially indebted to Dr. W. D. Hunter, in

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1 Note. This moth has been described by A. Busck in Proc. Ent. Soc. Wash., vol. XI, p. 201 (1909), from specimens sent from here, as *Amorbia emigratella,* and is supposed to be a recent immigrant from Mexico.

charge of the southern field crop insect and tick investigations of the bureau, for his able assistance and great personal interest in an effort to introduce insects which may be of great benefit to the agricultural industries of the islands. For this work, an insect-proof house was built in which the parasites can be safely handled. It is desired later to introduce parasites of other insect pests, especially aphids and coccids. Cultures of entomophagous fungi have also been received from Florida, through the courtesy of Prof. P. H. Rolfs, Director of the Florida Agricultural Experiment Station, and will be tried on our destructive Coccidæ in the fall.

After the first blossoming of the algaroba, numerous reports were received at the station of the destructive work of a caterpillar on the algaroba blossoms. For several years the larva of a Phycitid moth, *Cryptoblabes aliena,* has been known to affect the blossoms of the keawe, but it was not believed to be especially destructive. An investigation showed that there were two distinct caterpillars working on the blossoms, the Cryptoblabes larva and the caterpillar of a moth close to Archips.[1] As far as observation goes, the wandering of the caterpillars among the blossoms seems to prevent the natural formation of pods, and the result is likely to be a very short crop of beans. Reports from different sections of the islands indicate this, and as the stockmen depend largely upon the keawe bean for winter fodder, the serious nature of these two pests is at once appreciated. A more thorough investigation of the matter is contemplated.

The three or four last months of the year were devoted to the collection and systematic study of the Aphidæ present in the islands. The results of this work are given in the following "Synopsis of Hawaiian Aphidæ."

SYNOPSIS OF HAWAIIAN APHIDAE.

In the investigation of the Hawaiian fauna and its systematic elaboration, some of the groups of smaller insects, of great economic importance, received practically no attention whatever, due partly to difficulties in the way of preservation of specimens, and in some cases to lack of scientific interest in insects evidently not indigenous. The Aphidæ, or plant lice,

1 vide fn. p. 19.

among others, suffered such neglect, although Kirkaldy [1] twice gave lists of known species and described two species as new. The present paper, in which the number of species is increased to 21, four of which are described as new, represents as thorough a study of the family as was possible with limited facilities and time. The writer's collecting was almost entirely confined to Honolulu and its adjacent mountains and extended over less than a year. More extensive collection might have added to the list. The writer acknowledges with thanks the help and encouragement of many co-workers, and is under especial obligation to Mr. Kirkaldy for the loan of literature.

KEY TO GENERA.

1. Antennæ of seven segments 2
   Antennæ of less than seven segments 8
2. Antennæ inserted on a frontal tubercle 3
   Antennæ inserted directly on the head 6
3. Frontal tubercles approximate, head grooved ..... *Macrosiphum*
   Frontal tubercles not approximate, head smooth or convex 4
4. Nectaries cylindrical ..... *Myzus*
   Nectaries more or less clavate, at least not cylindrical 5
5. Second branch of cubital vein distorted so as to form a closed cubital cell ..... *Pentalonia*
   Second branch of cubital vein not distorted, wing venation normal ..... *Rhopalosiphum*
6. Cubital vein only once forked ..... *Toxoptera*
   Cubital vein twice forked 7
7. Nectaries longer than broad, cylindrical ..... *Aphis*
   Nectaries shorter than broad ..... *Myzocallis*
8. Antennæ with six segments ..... *Eriosoma* (*Schizoneura*)
   Antennæ with five segments ..... *Cerataphis*

Macrosiphum *Passerini.*

Antennæ nearly always longer than body, on distinct and approximate frontal tubercles; seventh joint mostly longer than

[1] vide Proc. Haw. Ent. Soc., vol. 1, pt. 3, p. 100 (1907), pt. 5, p. 206 (1908).

the third. Wings large, legs long and slender, nectaries long, cylindrical, tail long, ensiform.

There are five species of this genus found in Hawaii, to be distinguished as follows:

1. General color black, with capitate hairs.....*M. kirkaldyi*
   General color green, without capitate hairs..... 2
   General color brownish or yellowish..... 3
2. Greenish without darker markings on abdomen....*M. trifolii*
   Greenish with dark lateral and dorsal markings....*M. rosae*
3. General color dark reddish or brownish and hairy .....*M. sanborni*
   General color yellow with horseshoe-shaped marking on dorsum of abdomen of apterous female.....*M. circumflexa*

Macrosiphum kirkaldyi n. sp.

Apterous female. Dull black, the dorsum bearing transverse rows of white capitate hairs. Sometimes a tinge of dark red on head. Eyes dark red. 1st and 2nd segments of antennæ black, 3rd, 4th and 5th pale with black tips, 6th and 7th dusky black. Legs long and pale, the tips of tibiæ slightly brownish, tarsi black. Nectaries moderately long, pale, black at base. Tail black. Length 1.4 mm.

Winged female. Dull black, thoracic tubercles and head having at times a copperish tinge, in front of and behind prothorax bluish. Eyes dark red, ocelli clear and bordered with black. Antennæ dusky, segments 1 and 2, 6 and 7, and tips of 3, 4 and 5 black. Legs pale, tips of femora, tibiæ, and tarsi black. Nectaries moderately long, cylindrical, wider at base than at apex, mouth conspicuously rimmed, pale, black at base. Tail about half as long as nectaries, ensiform, edges serrate, with two backward-pointing bristles on each side, black, subanal plate fringed with white. Rostrum reaching 3rd coxæ, pale with black tip and base. Wings clear, highly iridescent, veins black and heavily shaded, stigma short, broad, shaded with black, venation abnormal, only one branch to cubital, stigmatic vein much curved, uniting with cubital and branch for part of its length. Antennæ extending beyond the body about one-third of its length, glabrous, 7th segment longer than 3rd, 4th and 5th subequal, 1st, 2nd and 6th smaller than 4th or 5th and

subequal. Third segment with 9-11 circular sensoria, 4th with 4, 5th with 1-4, 6th with one large sensorium. Antennæ on distinct tubercles and close together, tubercles gibbous on inner

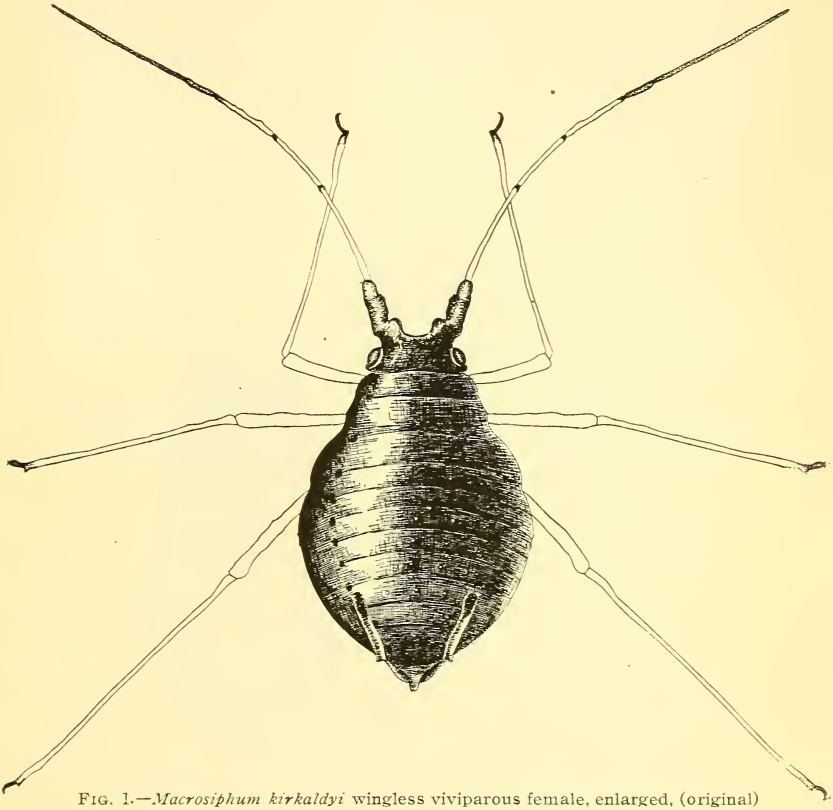

FIG. 1.—*Macrosiphum kirkaldyi* wingless viviparous female, enlarged, (original)

apical angle. Body covered with white capitate hairs. Length of body 1.25 mm. Length of antennæ 1.65 mm. Expanse of wings 4.5 mm.

Hab. Oahu, Tantalus (2000), Niu (2000), Palolo (1500) (O. H. S., D. T. F.); on *Acrostichum reticulatum*.

Macrosiphum trifolii Perg.

M. trifolii Pergande, Bul. 44, U. S. Bur. Ent., p. 21 (1904).

Apterous female. Light pea green and polished or somewhat pruinose, yellowish green towards head. Eyes red. An-

tennæ black except segments 1 and 2, which are yellowish green (in immature specimens segments 3, 4 and 5 are paler, only the tips black). Legs long, femora greenish at base, apically brownish, tibiæ brownish to black tip, tarsi black. Nectaries brownish in middle changing to black at apex and to green at base. Tail pale. Length 2.5 mm.—3.25 mm.

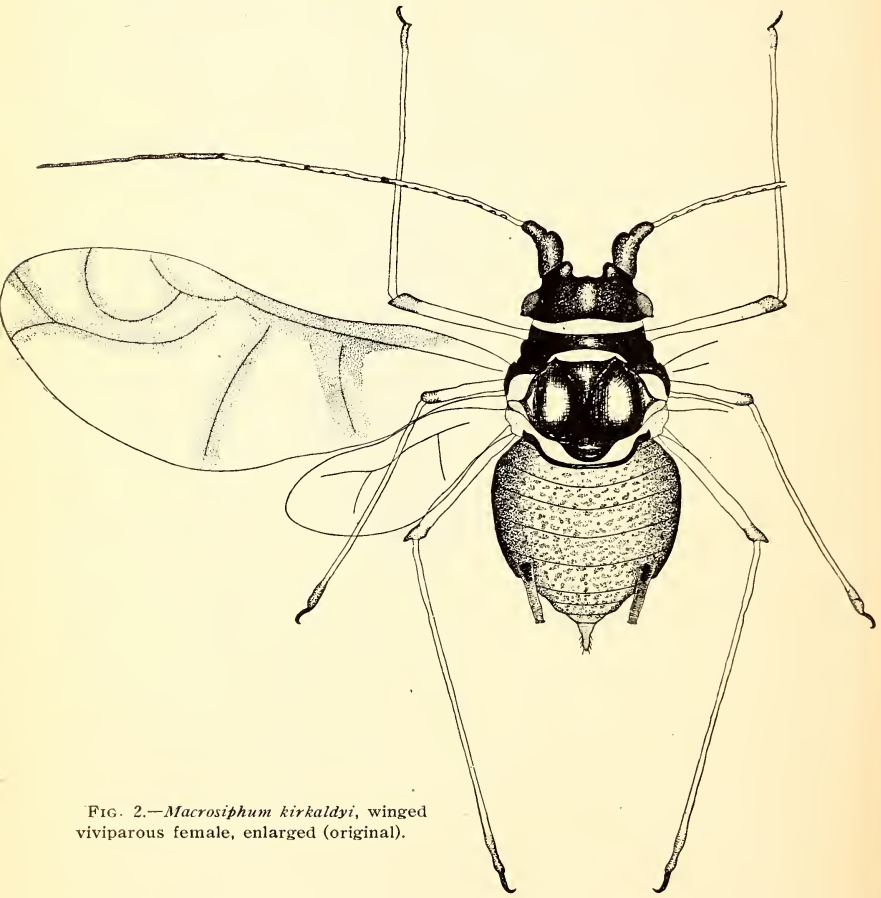

FIG. 2.—*Macrosiphum kirkaldyi*, winged viviparous female, enlarged (original).

Winged female. Light green, head and thoracic tubercles yellowish green. Eyes reddish brown, ocelli close to eye, clear and bordered with black. Antennæ black distally from near base of 3rd segment, 1st and 2nd segments and base of 3rd greenish yellow. Apical half of femora, tips of tibiæ and tarsi black, the remaining portions pale. Nectaries long and slender,

cylindrical, larger at base than at apex, dusky to black and greenish at base. Tail about half as long as nectaries, ensiform, densely covered with minute sharp spines and with four backward-curved hairs on each side, pale. Wings clear, veins thin and brownish, stigma long, narrow and greenish, venation normal. Antennæ extending to or slightly beyond tip of nectaries, hairs sparse and simple, seventh segment longer than third, fourth less than third, fifth less than fourth, sixth, first and second small. Sixteen small circular sensoria on third segment, one large circular sensorium at tip of fifth. Length of body 2.25—3.25 mm. Length of antennæ 3.37 mm. Expanse of wings 8.5 mm.

Hab. Oahu, Honolulu, Tantalus (2000) (D. T. F.); on *Sonchus oleraceus.*

Macrosiphum rosae (Linn.)

Aphis rosae Linn. Syst. Nat. 1, 2, 734 (1735)

Siphonophora rosae Koch. Pflanzenl. 178 (1854-1857)

Apterous female. Shining green. Eyes red. Antennæ long, as long as body, dusky. Legs long, yellowish green, tips of femora, tibiæ and tarsi black. Body long, ovate. Nectaries very long, reaching to or beyond tip of tail, curved, black. Tail long, ensiform, yellow. Length 2.25 mm.

Winged female. Green, head and thorax olive brown, prothorax greenish with darker transverse band. Abdomen lighter green with a row of five dark spots on each lateral margin, and obscure markings on the dorsum between segments two and five. Eyes red. Antennæ black except 2nd segment and base of third. Legs of moderate length, lemon yellow, the apices of femora, tibiæ and tarsi black. Nectaries long, thin, black, reaching to tip of tail, wider at base than at apex. Tail long, light yellow, ensiform, and bent slightly upward. Wings ample, clear, insertions and cubitus yellow. Stigma greenish, veins black, venation normal. Antennæ as long as or slightly longer than body, segments 3 and 7 subequal, 4th much shorter than the preceding but longer than 5th. Third segment with 14 circular sensoria, 8 on 4th segment, 1 on 5th, 1 on 6th. Length of body 1.85 mm. Length of antennæ 1.9 mm.

Hab. Oahu, Honolulu (D. T. F.); Hawaii, Mana (3500), Puuopelu (2000) (G. W. K.); on cultivated roses.

Macrosiphum sanborni Gillette.

M. sanborni Gillette. Can. Ent. 40, p. 65 (1908)

M. chrysanthemi (Oest.) Sanborn Kans. Univ. Sci. Bul., vol. 3, no. 1, p. 73 (1904)

Apterous female. Dark red, almost black, and polished, thorax lighter red, distinctly carinated, the body bearing transverse rows of hairs. Eyes dark red. Antennæ as long as or longer than the body, 3rd segment (except at tip) and base of 4th pale to yellow, the rest black. Legs stout, tip of femur, base and tip of tibia and tarsus black, rest pale to yellow. Nectaries vasiform, moderately long with wide base and narrow mouth, black. Tail about same length as nectaries but extending beyond them, concolorous, the chitinized portions black, ensiform, constricted at middle, with four backward curved hairs. Larvæ cherry red. Length 1.75 mm.

Winged female. Dark cherry brown, the head nearly black, thorax lighter red, tip of abdomen yellowish, body quite hairy, the hairs arranged in transverse rows. Eyes dark red. Antennæ black except base of 3rd segment which is yellow. Legs as in apterous form. Nectaries moderate, cylindrical but wider at base than at apex, with conspicuously rimmed mouth, black. Tail ensiform, upturned, black, about as long as nectaries but extending beyond them, and hairy. Rostrum reaching 2nd coxæ and black. Wings long and slender, extending beyond body by half their length, clear, iridescent, veins thin, dusky, stigma long and thin, yellow, venation normal. Antennæ as long as or longer than the body, more or less glabrous, 3rd segment longest, slightly longer than 7, about twice as long as 5, which is slightly less than 4. Third segment (and 4th) tuberculate with many sensoria, 5 and 6 each with one. Length of body 1.8 mm. Length of antennæ 2 mm.

Hab. Oahu, Honolulu (D. T. F.); on cultivated chrysanthemums.

Macrosiphum circumflexum (Buckt.)

Siphonophora circumflexa Buckton. Mon. Brit. Aphidæ, vol. 1, p. 130.

Apterous female. Yellow with black markings as follows: on prothorax toward lateral margins large spot outward and forward, a smaller one inward and backward, meso and meta-

thorax each large transverse marking, abdominal segments 1, 2, 3, 4 and 5, a large horseshoe shaped marking, curve directed backward, two small transverse markings on segments 6 and 7. Eyes dark red. Antennæ longer than the body, pale except at joints which are black, 7th segment dusky. Antennæ on well-defined tubercles. Legs pale or reddish to tips of tibiæ which are black. Nectaries pale to black rings which are more or less conspicuous. Tail conical, pale. Under side of body greenish yellow except head which is pale.

The winged form has not been observed.

Hab. Oahu, Tantalus (1500) (D. T. F.); on *Physalis peruviana* in the cup of the inflated calyx.

Myzus *Passerini.*

Antennæ nearly as long as the body, on frontal tubercles which are gibbous on inner side. First antennal segment also gibbous. Wings moderately long, venation normal. Nectaries moderately long, cylindrical. Tail moderately long.

There are two species of this genus in Hawaii, to be distinguished as follows:

1. Body of both apterous and winged forms wholly black, antennæ not as long as the body.....*M. citricidus*
   Body of apterous female yellowish green, of winged female generally green, only head, part of thorax and abdominal markings black, antennæ longer than the body.....*M. persicae*

Myzus citricidus Kirkaldy.

M. citricidus Kirkaldy. Proc. Haw. Ent. Soc., vol. 1, pt. 3, p. 100 (1907).

Apterous female. Form and color of *Myzus cerasi* (larva lighter). Eyes dark red. Antennæ black proximally and distally, segments 3, 4, and base of 5 whitish. Legs: most of femora, distal end of tibiæ and tarsi black, remaining portions whitish. Nectaries large, curved, wider at base than at apex, with inconspicuous rim, black. Tail large, conical, hairy, black. Small fleshy tubercle on thorax and succeeding segments. Antennæ nearly two-thirds as long as the body, on widely separated frontal tubercles. Length of body 2.15 mm.

Winged female. Form and general appearance of *Myzus*

cerasi. Black, shining, closely reticulate on tergites, abdomen above and below often widely dark brown medio-longitudinally. Eyes nearly black. Antennæ black, fourth and fifth segments white at base. Legs: femora black except at base, tibiæ whitish to tips, which with tarsi are black. Nectaries long, reaching tip of tail, slightly wider at base than at apex, not conspicuously rimmed, black at least basally. Tail conspicuous, about half the length of nectaries, ensiform, hairy, bent upward, black. Wings large, clear, cubitus and stigma whitish sordidly, veins pale fuscous, venation normal. Antennæ nearly as long as body, 7th segment longer than 3rd, 3rd and 4th subequal, each longer than 5th, 3rd segment with about 12 circular sensoria. A small tubercle on lateral margins of prothorax and others on lateral margins of abdomen. Antennæ on widely separated frontal tubercles. Length of body 1.75 mm. Length of antennæ 1.6 mm. Expanse of wings 5.25 mm.

Hab. Oahu, Honolulu (D. T. F.); Hawaii, Mana (G. W. K.); on *Citrus aurantium.*

Myzus persicae (Sulz.)

Aphis persicae Sulz., Kennzeichen Insecten, p. 105 (1761).

Aphis dianthi Schr., Fauna Boica II (1801).

Apterous female. General color yellowish green without black markings. Body long and tapering posteriorly. Eyes dark red. Antennæ and legs pale except at tips, which are dusky to black. Nectaries pale. Tail concolorous. Antennæ reaching base of nectaries, which are quite long. Tail long, ensiform. Length of body 1.8 mm.

Winged female. Head and thorax black or blackish. Abdomen green with dark (almost black) markings on dorsum of segments 4, 5 and 6, and sometimes extending to segments 3 and 7. Spots of similar color on lateral margins of segments 2, 3 and 4. Eyes dark red. Antennæ black. Legs pale, distal portions of femora, tibiæ and tarsi black. Nectaries long, thin, cylindrical (slight constriction at about middle), mouth conspicuously rimmed, black or blackish. Tail black, moderate, ensiform. Wings clear, iridescent, insertions yellow, stigma slightly dusky, veins thin, black, venation normal. Antennæ somewhat longer than the body, 7th segment slightly longer than the 3rd, 4th less but somewhat longer than 5th, 3rd seg-

ment with 10-12 circular sensoria in a single row. Length of body 1.75 mm. Length of antennæ 2 mm.

Hab. Oahu, Honolulu (D. T. F.); on *Brassica oleracea.*

Pentalonia *Coquerel.*

Similar to *Aphis* but with remarkable venation. Third discoidal vein and its first branch (cubital) straight and anastomizing with a deformed stigmal vein, so that there appears, 1st, an inferior nerve (3rd discoidal) extending to basal margin, 2nd, a superior nerve (cubital) which bifurcates, the inferior branch extending to the basal margin, the superior branch again bifurcating, its proximal member being simple, its distal member again bifurcating before the margin is reached: there are thus formed five apical cells with approximately straight boundaries.

Pentalonia nigronervosa Coq.

P. nigronervosa Coquerel. Ann. Soc. Ent. France, p. 279 (1859).

Apterous female. Mahogany brown and somewhat polished, the larvæ and pupæ usually paler. Eyes reddish. First and second antennal segments almost black, third pale brown, fourth and fifth pale to black tips, sixth and seventh almost black. Segment three without sensoria but four and five with the usual large sensoria near the tips. Legs normal, outer third of femora, tip of tibiæ and tarsi black. Median light area on head and thorax. Dorsum of abdomen in median elevated portion almost black. Length 1.4 mm.

Winged female. Darker than apterous, almost black, thoracic tubercles prominent and polished. Antennæ dusky, first and second segments black, third pale in basal portion. Legs as in apterous form. Nectaries of moderate length, incrassate, mouth flaring, with distinct rim, black. Tail short and inconspicuous, white. On each segment a transverse row of minute white hairs. Wings clear, veins strong and black, somewhat shaded, stigma grayish black. Venation abnormal, cubital vein two forked and distorted, the stigmatic vein uniting with the outer branch of the cubital so as to form a distinct closed cubital cell contiguous to the stigmal cell. Hind wings with

only one branching vein. Antennæ as long as the body, the first segment much the stoutest, frontal tubercles prominent and gibbous on inner apical angle, seventh segment much longer than 3rd, 3rd about as long as 4th and 5th together, 6th, 4th and 5th, and 1st and 2nd subequal in length. Third segment with about 8-9 sensoria, 4th with 6 sensoria, three of them near the middle of the segment, 3 near the distal end, 5th with 3 smaller circular sensoria, 5th and 6th with the usual large sensorium near apex. Length of body 1.8 mm. Expanse of wings 4.25 mm.

Hab. Oahu, Honolulu (D. T. F.); on cultivated banana (*Musa* spp.)

Rhopalosiphum *Koch.*

Antennæ on frontal tubercles which are not distinctly approximate, about as long as or longer than the body. Nectaries larger in the middle than at either end or distinctly clavate, moderately long. Tail more or less small and inconspicuous, sometimes conical.

Rhopalosiphum violae Perg.

R. violae Pergande. Can. Ent. vol. 32, p. 29 (1900).

"Apterous females dark cherry-brown and polished, the larvæ and pupæ generally somewhat paler. Eyes dark brown, third joint of antennæ more or less distinctly of a paler color than the body, the remaining joints black. Legs purplish, the femora darkest towards the end and the apex of the tibiæ and the tarsi black. Nectaries purplish. Head and thorax of the pupæ generally paler than the rest of the body.

"Winged females also dark cherry-brown or purplish-brown, the antennæ, thoracic lobes, terminal two-thirds or more of femora, apex of tibiæ and tarsi black; rest of the legs of a dull yellowish colour, with a tinge of purple. Nectaries and tail dusky. Wings clear, the veins strong and black and conspicuously shaded; stigma black; stigmal vein short and strongly curved. Antennæ of all, very long and slender, reaching considerably beyond the end of the body; joint 6 with its spur is much longer than the 3rd, joints 4 and 5 are subequal in length, and each of them somewhat longer than the 3rd; there are numerous sensorial tubercles on joint 3 and a few on joint 4,

while all of them are sharply serrate. The first joint is very much the stoutest, and bulging out strongly about the middle at the inner side; frontal tubercles prominent and gibbous at the inner apical angle. Legs long and slender. Nectaries clavate, reaching to the tip of the abdomen. Tail short and inconspicuous. Length of winged and apterous females about 1.6 mm. Expanse of wings about 5 mm."

I have copied Pergande's description of the species (supra) as my material was in such poor condition as to make it impossible to write an adequate description from it.

Hab. Oahu, Tantalus (1500-2000) (D. T. F.); on cultivated violets. I presume it was the same species that Mr. Kirkaldy observed at Puuopelu on Hawaii.

Toxoptera *Koch.*

Antennæ on no frontal tubercles, or on very inconspicuous ones, not approximate, sometimes as long as, usually a little shorter than the body. Legs moderate. Nectaries moderate, not as long as the breadth of the segment in which they arise. Tail conical. Cubital vein only once forked.

There are two species of this genus found in Hawaii, to be distinguished as follows:

1. General color of winged and wingless female black ..... *T. aurantiae*
   General color of winged female green, wingless female brownish yellow ..... *T. caricis*

Toxoptera aurantiae Koch.

T. aurantiae Koch. Pflanzenl., p. 254 (1854-7).

Apterous female. Dull black with sometimes a brownish tinge on head (the larvæ somewhat pruinose). Eyes nearly black. Antennæ nearly as long as body, black, 1st and 2nd segments black, 3rd, 4th, and 5th white with black at apex, 6th mostly black, 7th white with black tip. Legs fairly stout, front femora mostly brownish, black at tips, middle and hind femora mostly black, brownish at base, tibiæ pale dusky with black tips, tarsi black. Nectaries short, cylindrical, wider at base than at apex, mouth inconspicuously rimmed, entirely black. Tail small, black, conical and bent upward, beset with hairs. Length of body 1.52 mm.

Winged female. Somewhat smaller than apterous, black, abdomen on sides and backward from nectaries brown, a pair of tubercles on each side of thorax pale. Antennæ a little longer than the body, 1st and 2nd segments black, 3rd, 4th and 5th white with black apex, 6th mostly black, 7th white with black tip. Legs fairly stout, front femora brownish at base, black at apex, middle and hind femora black, tibiæ brown with black tip, tarsi black. Nectaries short, cylindrical, wider at base than at apex, entirely black. Tail conical, rather thick, black, beset with hairs. Wings clear, insertions yellowish, veins brownish, stigma long, narrow, black, venation normal, stigmatic vein extending from apex of stigma and much curved. Antennæ not approximate and hardly on frontal tubercles, 7th segment longer than 3rd, 4th and 5th subequal, 3rd with 8 large circular sensoria, smaller sensoria on 4th and 5th, on each of

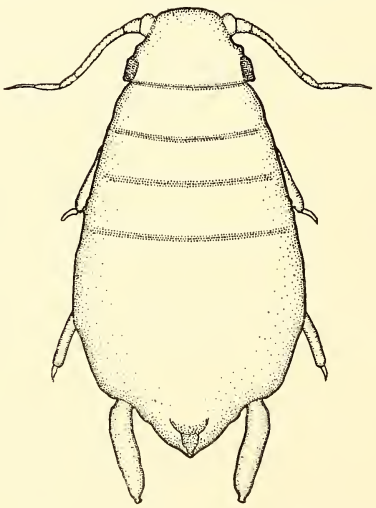

FIG. 3.—*Toxoptera caricis*, wingless viviparous female, enlarged, (original).

which there is the usual single large sensorium. Length of body 1.16 mm. Expanse of wings 4.3 mm.

Hab. Oahu, Tantalus (2000), Niu (2000), Palolo (1500) (O. H. S., D. T. F.); on *Pelea, Straussia, Coffea.*

Toxoptera caricis n. sp.

Apterous female. Brownish yellow, lighter at the margins. Eyes dark red. Antennæ, legs and nectaries concolorous. Tail

darker. Rostrum with black tip. The body is broadly oval and flat, so that the legs seem close together. Integument hard. Antennæ short, less than half the length of the body, third segment the longest, 7th which is filiform and about one-third of 3rd nearly equal to 4th, 5th still smaller, less than one-half of 4th. Nectaries very large, extending half their length beyond tail; base and apex much constricted, the mouth rimmed; otherwise broad for their length. Tail small, ensiform. Length of body 1.44 mm.

Pupa similar to apterous female with the exception of pale wing cases.

Winged female. Green, head and thorax dark olive brown, prothorax greenish yellow with dark olive-brown band. Abdomen light green. There are usually a few small dark-red spots toward the base in center on dorsum. Eyes dark red. Antennæ dark brownish black. Legs pale to tips of tibiæ, which with tarsi are black. Nectaries moderate, reaching beyond tip of body, pale to green, clavate and much bent. Tail short, conical and black. Wings ample, clear, iridescent, insertions light yellow, stigma long, thin, dusky, veins black. Cubital vein only once forked. Antennæ about two-thirds length of body, reaching base of nectaries, 3rd segment the longest, 7th less than 3rd but longer than either 4th, 5th or 6th, which are subequal, 3rd, 4th and 5th segments cicatrized with many circular sensoria, one large circular sensorium at tip of 6th. Length of body 1.5 mm. Length of antennæ .9 mm. Expanse of wings 4.65 mm.

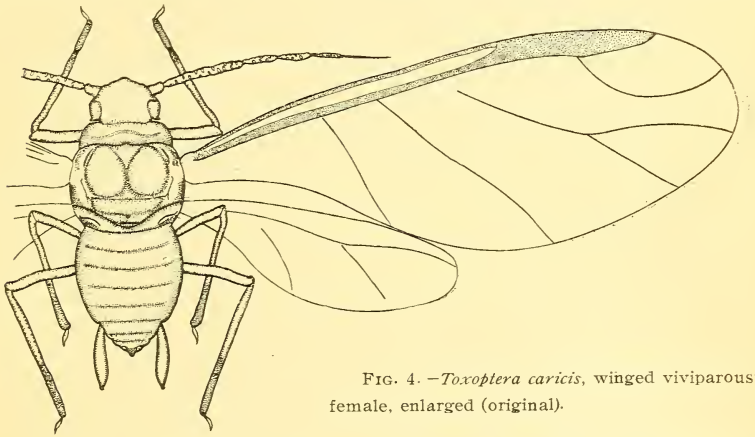

FIG. 4.—*Toxoptera caricis*, winged viviparous female, enlarged (original).

Hab. Oahu, Pauoa V. (1500-2000) (D. T. F.); on a species of *Carex*.

Aphis *Linnaeus.*

Antennæ on no frontal tubercle, or on very inconspicuous ones, usually shorter than the body. Wings rather short and broad, deflexed in repose, venation typical. Legs moderately long. Abdomen short and broad, rounded or obtuse behind. Nectaries moderately long, cylindrical or slightly incrassate, sometimes small. Style usually short, more or less thick, conical.

There are seven species of this genus found in Hawaii, to be distinguished as follows:

1. Nectaries conspicuously short, about twice as long as wide ..... *A. sacchari*
   Nectaries not so short, much more than twice as long as wide 2
2. Third antennal segment with not more than 12 large circular sensoria—from 3 to 12 3
   Third antennal segment with more than 12 large circular sensoria—14 to 20 5
3. General color black, apterous female with white waxy secretion on dorsum ..... *A. bambusae*
   General color green or mixed with green, apterous females without waxy secretion 4
4. General color green, sometimes with reddish tinge, dorsum much marked with black, 3rd antennal segment with 10-12 circular sensoria ..... *A. swezeyi*
   General color dark green to almost black, sometimes mixed with orange yellow, dorsum with lateral black spots, 3rd antennal segment with 3-8 circular sensoria ..... *A. gossypii*
5. Third antennal segment conspicuously cicatrized, wider than following segments, apterous female and larvæ covered with a mealy or woolly substance ..... *A. brassicae*
   Third antennal segment not conspicuously wider than the following segments nor cicatrized, apterous female and larvæ not covered with a woolly substance 6
6. General color of apterous females dark green ..... *A. maidis*
   General color of apterous females yellowish green ..... *A. myosotidis*

Aphis sacchari Zehntner.

A. sacchari Zehntner. Arch. Java Suiker. V, p. 551 (1897) and IX, p. 673 (1901).

Apterous female. Greenish (larvæ paler). Eyes dark red. Antennæ slightly more than half the length of the body, black distally, 1st to 5th segments pale, 6th and 7th black. Legs pale to tarsi, which are black. Nectaries conspicuously short, black. Tail moderately long, much wider at base than at apex, which is conical, black. Length of body 1.3 mm.

Winged female. Head, thorax and transverse band on neck black, prothorax and abdomen light to dusky green. Eyes dark red. Antennæ black, except base of third segment, which is green. Legs light to tarsi, which are black. Mid and hind femora sometimes dusky distally. Nectaries conspicuously small, black, wider at base than at apex, which has a distinct rim. Tail small, conical, black and hairy. Wings clear, insertions yellowish. Stigma dusky, veins black, venation normal. Antennæ two-thirds as long as body, 7th segment considerably longer than 3rd, 5th less but a little longer than the 4th. Third segment with about 7 circular sensoria. Length of body 1.6 mm. Length of antennæ 1.08 mm.

Hab. Oahu, Honolulu, and probably throughout islands where sugar cane is grown (O. H. S., G. W. K.); on sugar cane (*Saccharum officinarum*).

Aphis bambusae n. sp.

Apterous female. Black beneath flocculent white waxy secretion. Eyes reddish black. Antennæ generally a dull white, segments 1, 2, 6, and 7 towards tip black. Legs pale to tarsus which is black. Coxa and trochanter black, distal end of femur and proximal end of tibia slightly blackish. Nectaries short, not reaching the end of the body by twice their length, black. Tail short, conical, dusky with four pairs of hairs directed backward. Two lateral rows of black spots dorsally on abdomen converging at point opposite base of nectaries. Two lateral rows of black spots on venter which do not converge. Antennæ about as long as the body on slight erect tubercles. The waxy secretion is apparently absent across the thoracic region and around the base of the nectaries. Length 1.07 mm.

Winged female. Much smaller than the apterous form.

Waxy secretion absent. Color black. Eyes black. Antennæ dusky to black, the two basal segments black. Legs black to tip of the femur, tibia pale except extreme base and tip which are black, tarsus blackish. Nectaries small, slightly longer than tail, black. Tail small, dusky, with a pair of hairs which are directed backward. Wings extending greatly beyond body, clear, iridescent, stigma dusky, veins black, venation normal, antennæ about one-fourth longer than the body. Seventh segment the longest, about twice as long as 3, 3, 4 and 5 sub-

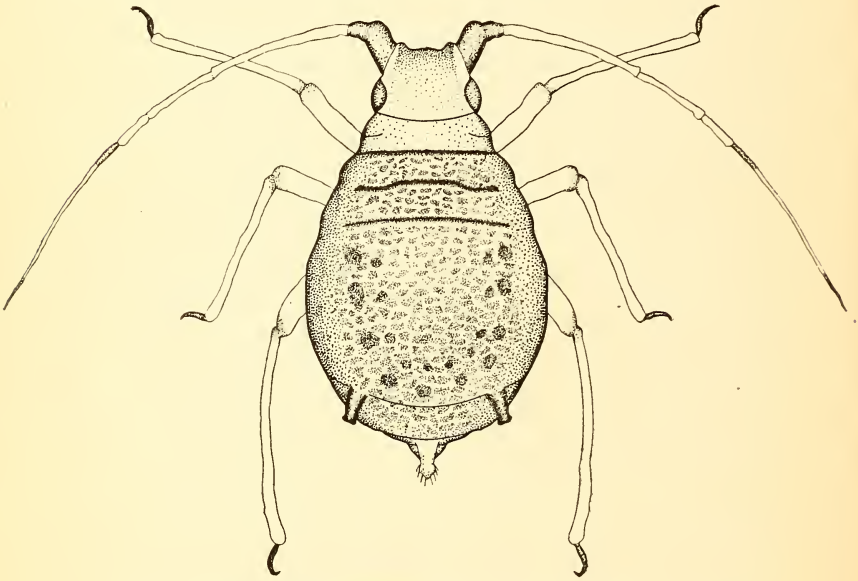

FIG. 5.—*Aphis bambusae*, wingless viviparous female, enlarged, (original).

equal. Third segment with 8 circular sensoria in a straight line and tubercular, 4th segment with 6 and also tubercular, 5th segment with 7 but only slightly tubercular, 1st segment broad. Length of body .8-1 mm. Length of antennæ 1.17-1.25 mm. Expanse of wings 3.4 mm.

Hab. Oahu, Honolulu (D. B. K., D. T. F.); on a bamboo (*Phyllostachys?*).

Aphis swezeyi n. sp.

Apterous females. General color green, mottled with black, sometimes lightly covered with mealy bloom. Larvæ lighter

green without black markings. Eyes dark red. Antennæ about half the length of the body, dusky to black, bases of segments 3 and 4 dirty white. Legs long, black, base of femora and tibiæ except tip white. Head black, thoracic segments with broad, black transverse bands and lateral spots. Abdominal segments to one in front of nectaries with large black lateral spots and dorsal central markings which decrease in size caudad. Segment in front of nectaries has wide, thin, transverse, black marking (broadly interrupted), segment with nectaries has some indistinct central dorsal markings, the two following seg-

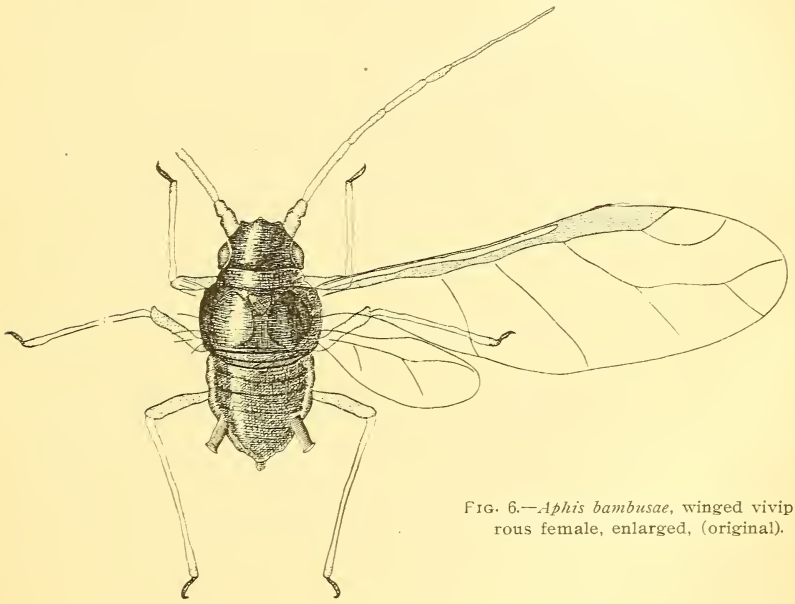

FIG. 6.—*Aphis bambusae*, winged viviparous female, enlarged, (original).

ments each a transverse black band. There are six large lateral spots in front of nectaries and a smaller spot just behind them. On the ventral surface, which is green, obscured by whitish bloom, there is a lateral row of smaller markings from the 1st segment caudad. Thoracic and abdominal tubercles well marked. Nectaries short, not reaching tip of tail, cylindrical, more or less imbricated, with distinct rim, black. Tail short, conical, tip black. Length 1.62 mm.

Winged female. Head black, thorax shining black, prothorax with transverse black band, on either side of which it is green or reddish, abdomen dull green with a reddish tinge.

There are three large lateral black spots on each side, with corresponding thin transverse markings extending medad in front of nectaries; behind nectaries is one lateral black spot on each side and the following two segments have each a transverse black band. Eyes dark red. Antennæ black except base of third segment. Legs dusky to black except base of femora and tibiæ, only the point of which is black. Nectaries

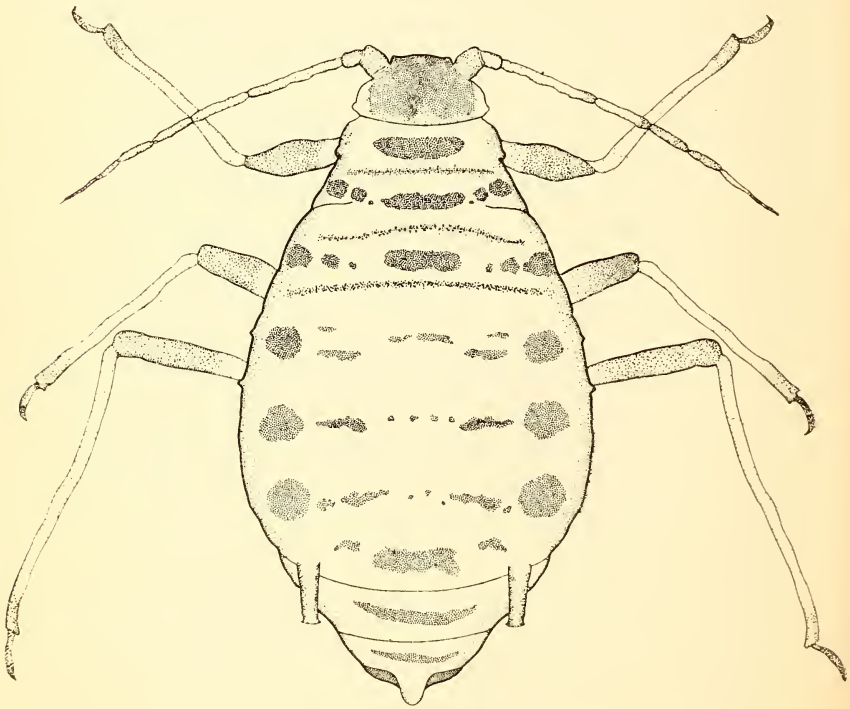

FIG. 7,—*Aphis swezeyi*, wingless viviparous female, enlarged, (original).

very short, not reaching tip of tail by much more than their length, black, conspicuously rimmed. Tail moderately long, black. Wings clear, insertions reddish, cubitus, stigma and veins dusky. Venation usually normal, sometimes second fork of cubitus absent, stigmatic vein much curved. Antennæ a little more than one-half the length of the body, third segment longest, nearly a third longer than 7th, 4th considerably less than 7th but longer than 5th, 6th smallest; third segment with

10-12 circular sensoria, one on the 4th, the 5th and the 6th. Length of body 1.61 mm. Length of antennæ .9 mm.

Hab. Oahu, Halawa (O. H. S., D. T. F.); on *Gnaphalium*.

Aphis gossypii Glover.

A. gossypii Glover. Pat. Office Report 1854, p. 62.

A. gossypii Glover. Pergande, Ins. Life 7, p. 309-315 (1895).

Apterous female. Very variable in color, light lemon yellow to dark greenish with obscure markings and even dull and polished black,[1] sometimes pulverulent with a bluish tinge. Eyes red to deep black. Antennal segments 1, 2, 6, 7 and tip of 5 dusky to black, remainder pale. Legs pale to tips of tibiæ, which with tarsi are black, femora sometimes blackish distally. Nectaries short, black. Tail short, conical, concolorous with dusky tip and bearing two backward curving hairs. Antennæ about half as long as body or slightly longer. Prominent conical and fleshy tubercles on either side of prothorax and behind nectaries and four smaller tubercles on each side of abdomen in front of nectaries. Length of body 1.2-1.8 mm.

Winged female. Head, thorax and transverse band on neck black, thoracic tubercles conspicuous and shining, neck and prothorax green, sometimes very dark, abdomen orange yellow in front, green behind, or blackish with green markings. When light, four lateral black spots can be distinguished, the last at base of nectaries. Eyes dark red to nearly black. Antennal segments 1 and 2 black, 3 mostly black, white at base, 4, 5 and 6 white basally, black apically, 7 black. Legs pale to tips of

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[1] Note. It is difficult to decide whether there is one or two species on this long list of food plants. The wide differences in size and color led me to believe at first that there were two distinct species, but a more careful examination of a great mass of material shows no distinguishing character that is constant for any part of it. I am inclined to believe, however, that the aphid found on *Medicago denticulata*, *Phaseolus lunatus* and *Portulaca oleracea* is different from *A. gossypii*, which as seen on cotton is never a polished black. Mature apterous individuals of the aphid on the above-mentioned plants have large, swollen abdomens, which are polished black in color with surface reticulation. The alate forms are also sometimes somewhat polished black, obscuring a dark green beneath. It is interesting to note in this connection that Dr. Filippo Silvestri in his report on a recent visit to the Hawaiian Islands (Bol. Quind. Soc. Agr. Ital., 14 (1909), no. 8, p. 344) states that he observed *Aphis papaveris* on beans. The species may be *A. papaveris* or *A. medicaginis*, but it does not answer closely the description of either of these species, and it will be necessary to make more extended observations to settle the matter.

tibiæ, which with tarsi are black, hind and sometimes mid femora black. Nectaries black, moderately long, cylindrical, wider at base than at apex, mouth not conspicuously rimmed. Tail concolorous, pale or dusky, moderately long, conical. Wings clear, iridescent, insertions and cubitus pale yellow,

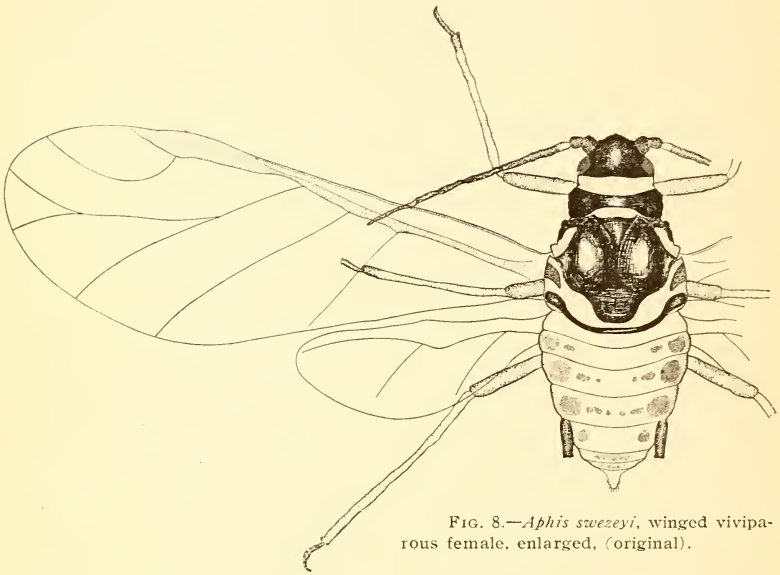

FIG. 8.—*Aphis swezeyi*, winged viviparous female, enlarged, (original).

stigma yellow to dusky, veins brown, stigmatic vein much curved, venation normal. Antennæ one-half to two-thirds as long as body, in latter case nearly or quite reaching base of nectaries, 7th segment a little longer than 3, 4th and 5th subequal and each less than 3. Third segment with 4-8 large circular sensoria. Length of body 1.2 mm.-1.8 mm. Length of antennæ about 1 mm.

Hab. Oahu, Honolulu, Wahiawa, Waipahu mauka, Kunia, Tantalus (D. T. F.); on *Gossypium, Cucumis, Arum esculentum, Hibiscus rosasinensis, Medicago denticulata, Phaseolus lunatus, Portulaca oleracea, Cuphea, Bidens.*

Aphis brassicae Linn.

A. brassicae Linn. Syst. Nat. 1, 2, p. 734 (1735).

A. brassicae Linn. Fab., Ent. Syst. IV, p. 218.

A. brassicae Linn. Koch, Pflanzenl., 149-150 (1854-57).

Apterous female. Long oval, plentifully covered with a whitish mealy coat. When this is removed, the body beneath

is greenish with a row of 8 black spots a little removed from lateral margin. Eyes black. Antennæ green with black tips, shorter than body. Legs black. Nectaries very short, black. Tail small, black. Length of body 2 mm.

Winged female. Head, thoracic tubercles and transverse bar on neck black, prothorax and abdomen yellowish green with a row of fine punctures on each lateral margin and several obscure transverse dorsal markings. Eyes black. Antennæ dark brown to black. Legs dusky brown, pilose. Nectaries dark brown, black at tips, short. Tail small, conical, hairy, dark green or brown. Wings clear, with stout coarse veins and dark stigma. Antennæ about three-fourths as long as body, 3rd segment longer than 7th, 4th less than 7th but longer than 5th, third segment much cicatrized with more than 20 circular sensoria. From the fourth segment to the tip the antennæ are much more slender than in 3rd and basal segments. Length of body 2 mm. Length of antennæ 1.5 mm.

Hab. Oahu, Honolulu, Wahiawa (D. T. F.); on *Brassica oleracea*.

Aphis maidis Fitch.

A. maidis Fitch. N. Y. Rep't 1, 318 (1855).

Apterous female. General color dull dark green, the head, bases of nectaries and lateral and caudal margins generally dull black, body emarginate. Eyes dark red. Antennæ dusky to black proximally and distally, 3rd, 4th and 5th segments more or less pale, antennæ about half as long as the body. Legs black, femora sometimes pale. Nectaries black, not reaching tip of tail by more than their length. Tail black. Length of body 1.4 mm.

Winged female. Head, thorax and wide band across neck black, thoracic tubercles prominent. Neck on either side of band dark green. Abdomen light green, five lateral black spots, four before and one back of nectaries. Eyes dark red. Antennæ black. Legs black, front femora sometimes pale. Nectaries small, not reaching tip of tail by their length, sometimes incrassate, without conspicuous rim, black. Tail small, hairy, with subanal plate black. A distinct fleshy tubercle on lateral margins of penultimate abdominal segment. Wings clear, insertions and cubitus green, stigma dusky, veins thin and brown, venation normal. Antennæ more than half as long as the body,

3rd segment longer than 7th, 4th slightly longer than 5th but shorter than 7th. Third segment with 14 circular sensoria. Length of body 1.5 mm. Length of antennæ 1 mm.

Hab. Oahu, Honolulu, Kunia (D. T. F.); on sorghum (*Andropogon vulgare* var. *saccharatum*), corn (*Zea mays*).

Aphis myosotidis Koch.

A. myosotidis Koch. Pflanzenl., p. 57 (1854-57).

Apterous female. Yellowish green. Eyes dark red. Antennæ pale to sixth segment, 6th and 7th segments black. Legs pale to dusky, tarsi black. Nectaries concolorous, their tips black. Tail short, thick, hairy, concolorous. Body emarginated. Pupæ greenish.

Winged female. Head and thorax shining black, thoracic tubercles prominent, prothorax and neck green with a transverse darker band. Abdomen green with a darker area caudad of 2nd abdominal segment, which behind the nectaries takes the form of two transverse bands; four black spots on each lateral margin in front of nectaries. Antennæ black. Legs greenish to dusky, tips of femora, tibiæ, and tarsi black. Nectaries short, not reaching tip of tail, cylindrical and distinctly rimmed, black, base greenish. Tail short, thick, tip rounded, beset with hairs, concolorous, black beneath. Wings clear, insertions and cubitus pale greenish, stigma dusky, stigmatic vein much curved, nerves thin, black, venation normal. Antennæ short, not reaching base of nectaries, 7th segment a little longer than 3rd, 4th longer than 5th but only three-fourths the length of the 3rd, third segment with 15-16 large circular sensoria and a few smaller ones, the usual large circular sensorium at tip of fifth segment. Length of body 1.5 mm. Length of antennæ 1.1 mm.

Hab. Oahu, Tantalus (1000), Pauoa V. (1000) (D. T. F.); on *Erechtites* sp.?

Myzocallis *Passerini.*

Antennæ on no frontal tubercles, smooth, seventh segment longer than 6th, front wings with cubital vein twice forked, posterior wings with two oblique veins, nectaries tuberculiform or subobsolete.

Myzocallis kahawaluokalani Kirkaldy.

M. kahawaluokalani Kirkaldy. Proc. Haw. Ent. Soc., vol. 1, pt. 3, p. 101 (1907).

"Winged female. Pale yellowish, marked with pale brownish fuscous, principally as follows: Head dorsally with a mediolongitudinal line and a speck on each side of this, and lateral margins broadly, posterior margin narrowly; irregular, broad, submedian bands down the pronotum, lateral margins narrowly; a suboval, interiorly pale, sublateral spot on mesonotum, a goblet-shaped mark in the middle (the bowl anteriorly, the stem posteriorly), posterior margin broadly; a large irregular transverse spot near the base of abdomen; antennæ whitish, first two segments and apices of 3rd-5th pale brownish fuscous. Eyes bright pale vermeil. Abdomen dorsally and sublaterally with numerous fuscous-ringed tubercles which bear scarcely perceptible hairs, with two contiguous fuscous mammiform tubercles near the base in the middle, etc. Tegmina hyaline, very strongly particoloredly iridescent, subcostal ('costal') cell and stigma, veins and a V apically, pale fuscous. Legs pale, fore and middle femora with a fuscous annulation, hind femora broadly fuscous, apically, hind tibiæ fuscous basally; coxæ more or less fuscous. Honey-tubes short, pale, fuscous. Antennæ scarcely as long as the body, 6, 5, 30, 24, 22, 14, 12, the seventh not really separated from the sixth. Stigma rather long, longer than broad, curved. Length to apex of abdomen about 1.25 mill., to apex of flight organs about 2 mill.

"Hab. Oahu, Honolulu, on *Lagerstroemia indica,* an introduced plant (G. W. K.); also on other shrubs.

"Nymph. Pale yellow, eyes red as in adult. Head, nota and abdomen multituberculate dorsally and laterally, each tubercle with a black capitate bristle."

I have copied the original description of this species, (supra) as I have not seen specimens myself.

Eriosoma *Samouelle* (Schizoneura *Hartig*).

Antennæ six-segmented, cubital vein only once forked. Posterior wings with two oblique veins, which usually originate close to each other, sometimes in contact.. The antennæ are short, those of the winged individuals extending beyond the end of the thorax, those of the apterous individuals usually

reach only to the end of the prothorax, third segment longest. No visible nectaries. Body usually rather broad, elliptical in the winged and broadly ovate in the apterous individuals. Colors are usually black, brown or reddish. Rostrum rather long and slender.

Eriosoma mali Samouelle.

Eriosoma mali Samouelle. Entom. Useful Companion, p. 232 (1819).

Schizoneura lanigera (Hausm.), Fitch, Cat. Homoptera N. Y. 67 (Lint. Rep. NY. Ent. 9, 411).

"Apterous individuals. About one-tenth of an inch long; reddish brown and covered above with a white, cottony secretion; antennæ short, and pale yellow; legs yellowish; knees brown; without honey-tubes, but with a circular cicatrix in place of each.

"Winged individuals. Antennæ shorter than the head and thorax, and varying in color from brown to black; head and thorax black, a brownish ring at the collar; the abdomen chocolate brown; legs brownish; wings hyaline with the veins and stigma deep brown; body enveloped in a white, cottony secretion. Serville and Amyot give the length of the apterous individuals as only eight-hundredths of an inch; they described the winged individuals as less and with the body almost naked."

I have copied the description given in Thomas,[1] as my material was in such poor condition as to make it impossible to write an adequate description from it.

Hab. Hawaii, Waiki (4500) (J. E. H.); on apple (*Pyrus malus*).

Cerataphis *Lichtenstein.*

Antennæ five segmented, the first two segments smooth, the remaining ones ringed. Third segment the longest, fourth and fifth nearly equal. Eyes large. Nectaries obsolete. Eyes of larva nearly obsolete. Head furnished with two minute characteristic frontal horns. Legs and antennæ very short and largely concealed by a disc of waxen filaments arising from peripheral glands.

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[1] Thos. Rep't Ent. Ill. 8, p. 126 (1880).

Cerataphis lataniae (Boisd.)

C. lataniae Lichtenstein. Bull. France (6) 2, p. 16 (1882).

"Apterous female. Size of body 1.52x1.27 mm. Antennæ .25 mm. Coccus-like. Color rich brown, to the naked eye nearly black. Form oval or nearly circular. Edge of the body terminated by a string of minute transparent glands from which a clear disc of wax-like substance is secreted. This disc is striated and slightly fimbriated. It entirely surrounds the insect and hides the antennæ and legs below. In the spring of the year two or three pale folds occur across the dorsum of the insect.

"Antennæ very short; four jointed, the first and second joints nearly equal; the third the longest, and about double the length of the second. The fourth joint ends in a considerable nail, which, added to the rest, makes the whole joint nearly as long as the third. The front is furnished with two short projections or horns, the use of which is unknown. Eyes very minute; brown. Legs very short and normally formed like *Aphis;* ending with the usual tarsus and two claws, without the capitate hairs to be seen in coccus.

"Rostrum about one-fourth the length of the body. Cauda tuberculate, with two small papillæ. The under side is paler and mottled with brown.

"The young, born from the above insects, are much less coccus-like and do not greatly resemble their parents. After a short time they moult and become of a pale, ochreous green color. The wax glands soon after show themselves at the circumference of their bodies, and the growth of the disc is rapid and very interesting under the microscope.

"Winged female. Expanse of wings 4.06 mm. Size of body 1.77 mm. x 1.01 mm. Antennæ .88 mm. The imago apparently is very rare, for only three mutilated specimens are at present known. It has not yet been taken in England; but I have been able to make the above measurements from a specimen mounted by M. Richter of Montpelier.

"General color yellow. Antennæ with five articulations: the last three joints are much ringed. Vertex flat and without the horns seen in the larva. Eyes large; stemmata obvious. Wings folded flat on the back. Cubital vein is once forked, and it does not reach to the cubitus. First and second oblique veins unite

just before they touch the cubitus. Rostrum reaches to the second coxæ. Legs short, tarsi with two claws.

"The general appearance of the larva is so coccus-like that the venation shown by the imago is a little unexpected."

I have copied from Buckton [1] as the three or four specimens in my collection could not be used to frame an adequate description.

Hab. Oahu, Honolulu (G. W. K., D. L. VD.); on fan palm (*Pritchardia*).

1 Buckton. Monograph British Aphidae, vol. IV, p. 198.

REPORT OF THE HORTICULTURIST

By J. E. Higgins.

FRUIT-MARKETING INVESTIGATIONS.

The chief work in horticulture, during the first part of the year was a continuation of fruit-marketing investigations. Attention was given entirely to pineapples and the results of the work were reported in Press Bulletin No. 22.

PROPAGATION INVESTIGATIONS.

Citrus Fruits.

Considerable time has been given to studies in the propagation of citrus. Much difficulty has been experienced by those who have attempted to bud the citrus in Hawaii, and many failures have been reported. Information of similiar failures, even in the work of experienced propagators, has reached us from the Philippines. A careful study was therefore made of prevailing conditions and the difficulties to be overcome. The methods of budding used were those common in citrus culture and known as "shield budding," with a "T" shaped incision; with an inverted "T" and with right-angled and curved incisions. The two latter were used only with angular budwood and the curved incision was adopted only in old bark. While reasonable success can be expected from any of these, it is recommended that those who have difficulty in budding should adopt the ordinary method with the inverted "T." This is described in Bulletin No. 9 of this station, and in all works relating to citrus propagation. The tying may be done with raffia or strips of cotton which have been dipped in melted wax. If the latter are used, they should be held tightly in place by twisting together the ends. These experiments have added nothing new to the knowledge of methods of budding, but have discovered the causes which are believed to be chiefly responsible for the numerous failures reported, and have also afforded opportunities for the testing of remedies, thus point-

ing the way to success. The chief causes of failure are poor bud-wood, lack of vigor in the stocks, and insect attack.

Insects are frequently the sole cause, and the others, only subsidiary; but whatever may be the reason for the lack of vigor, whether it be infertility of soil, insufficiency of moisture, insects, or diseases, it must be removed and a vigorous, healthy condition restored before budding can be successful. Only when there is a comparatively rapid multiplication of cells, can the bud-shields and the stock unite. The bud-wood should be well matured and from a healthy growth. If selected before the most active growth begins, in the spring, it can be preserved in sphagnum moss until wanted. The moss,after being soaked in water, should be wrung out as dry as possible. It will then retain sufficient moisture to prevent the withering of the bud-wood, but will not induce decay. Spread out a thin layer of this moss on a sheet of heavy wrapping paper, place the bud sticks on it and roll up the package. It will be necessary to open the package every two or three weeks and again dip the moss in water. Bud-wood has been kept in excellent condition in spagnum moss at this station for several months.

Insects are the most prolific source of trouble in budding citrus in Hawaii. The work of testing methods of control has been carried on in cooperation with the entomological division of the station. Several species of insects have been very prevalent during the year and have thus afforded good opportunity for studying means of control. Chief among these insects are the following:

Scale insects and mealy-bugs.—A mealy-bug (*Pseudococcus filamentosus*) is prevalent on all species of citrus trees in Hawaii. Not only does it greatly reduce the vitality of the tree, but if an incision is made in the bark of an infested tree, as is done in budding, it is quickly occupied by a new colony of mealy-bugs. These rapidly multiply, cover the bud and destroy it. The young are so minute and so near the color of the bark that the new infestation may not be observed until the colony is well established.

The purple scale and the Florida red scale are also very destructive to citrus trees and if not checked, render budding extremely difficult.

Remedies. The most effective remedy for such scales and mealy-bugs has been fumigation with hydrocyanic acid gas.

In most instances, one treament has been sufficient to rid the tree of the pests (see remarks below, relating to fumigation). Ladybirds, (Coccinellidæ) do much to hold some scale insects in check, but up to the present time, at this station, they have not proved sufficient for the task of holding in control the three species mentioned above to a degree sufficient for the purposes of budding.

Climbing cutworms have been very destructive to many crops on Oahu during the year, and were numerous in the citrus orchards where most of the budding was performed. The damage consists in the devouring of the bark of the bud or budshield, or if this has escaped until the new shoot appears, the latter is girdled or completely cut off. It has not been found difficult to destroy these insects by placing poisoned bran on the surface of the soil about the trees. A small amount is sufficient and the remedy is effective and inexpensive. It consists in the following:—Paris green, ¼ pound, wheat bran, 10 pounds, sugar (brown), 1 pound, water, sufficient to moisten. Mix the Paris green, bran and sugar while dry and add a little water but not enough to prevent crumbling.

Archips postvittanus.—This insect in the larval stage, does much injury by folding the new leaves and also by eating the foliage. The remedy applied has been arsenate of lead in the proportion of 5 pounds to 100 gallons of water.

Aphids.—These are familiar to all as small greyish-black insects, some being winged and inhabiting the youngest growth in such numbers as frequently to cover the branch. They are usually overtaken by their natural enemies, but it sometimes becomes necessary to apply weak solutions of whale oil soap to assist the shoot while young.

Citrus Stocks.

The citrus stocks being tested run in parallel rows and consist of the following:—Rough lemon, sweet orange, shaddocks and seedlings from California grown pomelos. This is about the order also in which they stand at the station in their vigor of growth and their ability to produce growth in the inserted buds. They are so arranged in the orchard that each important variety of orange, lemon, or pomelo is budded on each of these stocks. Plate I shows six months' growth of

a Bahia or Washington Navel orange on a common sweet orange stock.

Seasons for budding.—The budding of the citrus trees was done during January, February, March, and April and appeared to be equally successful in all of these months if the individual trees were in active growth. How much longer it could have been continued, we do not know. The buds set early in the year are, of course, ahead in point of growth.

MANGO PROPAGATION.

The system in vogue in mango propagation, known as "patch-budding," has been practiced for several years. It has been defective as a commercial system because it requires that both the bud-wood and the stock shall be in a condition of rapid growth when the work is being done, and further, because the operation cannot be performed with sufficient rapidity. It was, therefore, sought to devise a method of budding the mango which would be an improvement in these or other particulars. The device that has been adopted consists essentially in the application of shield-budding with the inverted "T", using well matured wood as in patch-budding, and cutting the "T" and the shield very long. The incision is usually made six or seven inches long and the shield, about three or four inches. By this method, budding can be performed when only the stock is in active growth and the work can be done much more rapidly. Full instructions, together with data relating to the histology of the bud-union, are described in Bul. No. 20.

Inarching.—This method of propagating the mango has been, to a large degree, supplanted by budding in the practice of this station. It has been found very useful, however, in dealing with valuable trees that have become pot-bound or otherwise stunted. Mango trees have been received by mail and by freight from long distances. It requires considerable time for these to recover and some have never made a satisfactory growth, even when planted in the orchard with the best of care. The plan has been adopted of inarching a branch of such trees to the trunk of a vigorous seedling, later cutting off the whole top just above the union. For this purpose, the pot is plunged in the soil at the root of the seedling. This aids in maintaining uniform moisture in the pot, and also in plac-

ing the graft low on the stock. On a well established seedling root-system a single branch thus inarched will often make more growth in six or seven months than a whole tree placed in the orchard on its stunted root-system, could make in a year or two. After a month or two, when the inarching process has become complete, the potted tree can be removed to the side of another seedling and a second branch may be grafted. This has been found to be the best use that can be made of new introductions of mangoes.

AVOCADO PROPAGATION.

Some preliminary work has been done in avocado budding to determine the most satisfactory methods and season for such operations.

RECORDS.

The system of records of plantings and of the life history of plants in the horticultural division has been evolved as the needs of the work demanded. The system at present consists of the following:—

1. Accession book.
2. Alphabetical card index.
3. Loose-leaf note books.
4. Maps of fields.
5. Photographs.

In the accession book, as now used, very little is recorded except the date, the name, and the number in its numerical order. This affords a ready reference from any label number. The card index is arranged alphabetically. Here are recorded all the data available at the time of planting, except when a large amount of detail is necessary. In most instances, the card has proved sufficient for the whole record from planting to the present date. In the more elaborate experiments, loose-leaf note books are used and indexed by subject referring also to the accession numbers.

During the year just closed, the four cultivated fields of the station, in which are most of the plantings of the horticultural division, have been carefully surveyed and mapped. The station is greatly obligated to the Survey Department of the Territory of Hawaii for cooperation in this work in the making

of the original surveys and outline maps. Mr. C. J. Hunn, assistant horticulturist, has located all plants and recorded on the maps their position and number. Plate II shows a general view of these four fields, designated as fields A, B, C, and D. Each of these fields is divided into sections running from south to north. The sections are determined either by natural boundaries or by the character of the more permanent plantings; and are designated by Roman numerals. Where necessary, these sections are cut into divisions running throughout the entire length of the section. These divisions are designated by Arabic numerals and are numbered from left to right, as are also the rows. Further subdivision has not been found necessary up to the present time, but can be adopted as required. To illustrate, the index card "*Mangifera indica,* No. 1942" indicates the location of this trees as "C. IV. R. 3. The tree can immediately be located in Field C, Section IV and Row 3. (see Plate III). This field being narrow, no divisions are used. A tree in Field B might be designated "B. II. 2, R. 1. It would be found in Section II, division 2, row 1.

A very convenient use is made of this mapping system in loose-leaf note book records. Certain sections are photographed and the print inserted where needed in the notes. For example in Field C, section IV (see Plate III), which includes the mango orchard, considerable work has been done in budding and inarching on certain trees. It adds much to the convenience and accurracy of records to have a map of this section in the note book.

This mapping has required much time and patient effort at the beginning, but will result in economy of time and in greater accurracy in the making and availability of all records.

DEVELOPMENT OF EXPERIMENTAL ORCHARDS.

There are being developed, for experimental use, citrus, mango, and avocado orchards and also miscellaneous collections of fruit plants. These are already being used for experimental purposes. In connection with the propagation studies a large part of the citrus orchard has been budded to the leading varieties of orange, lemon, pomelo, lime and other species.

The propagation work with mangoes has afforded a similar

opportunity to change part of the seedling plantings into an orchard of varieties of known or reputed merit.

The Use of Hydrocyanic Acid Gas in Orchards.

In cooperation with the entomological division, a test has been made of the adaptability of hydrocyanic acid gas to Hawaiian conditions and of the efficiency of this gas in destroying certain insects not common where fumigation methods have been most carefully worked out.

The remedy has been found so effective in destroying the mealy-bug on citrus trees, *Pseudococcus filamentosus;* and the avocado mealy-bug, *Pseudoccus nipae,* as well as the Florida red scale, and the purple scale which have long been held in check by this means in the citrus belt of the mainland, that it has been adopted in orchard treatment at the station to the exclusion of oil sprays whenever the work of the natural enemies available proves insufficient for the task. The *P. filamentosus* is the more difficult to kill, because of its very heavy covering of cotton-like fllaments; but when fumigated while the trees have no new growth, even the eggs of this insect have been destroyed without injury to the foliage. It is necessary to remove a few inches of soil from the crown so as to expose to the gas, the insects on this part of the tree.

COVER CROPS.

The use of cover crops in the station orchards during the rainy season has become an established practice. Only the jack bean and cowpea of the clay type have been used during the year as cover crops since these proved best adapted to the purpose of any legumes tested in earlier trials. The cowpea is a rapidly maturing crop, furnishing a large amount of green manuring and remaining green as long as necessary for the average rainy season. If the wet weather should be prolonged, the cowpea might pass the stage of best growth for green manuring before it would be safe to open the ground to the washing of rains. The seeds were planted in Field C on January 2 and 4, the rainy season having apparently begun. The first flowering was observed March 17, and the crop was plowed under April 20 and 21.

The cowpea is very subject to the attacks of a species of aphid (*Aphis medicaginis*) and if the natural enemies of the latter are not present, the whole crop may be destroyed. A severe attack of aphids occurred in the plantings referred to above, and for several weeks the plants made practically no progress. Later, six or seven species of ladybirds (Coccinellidæ), multiplied rapidly and completely overcame the aphids, so that early in March the plants were again in vigorous growth and very rapidly covered the ground. These experiences give rise to two practical suggestions. If cowpeas are to be used as a cover crop during the seasons when aphids are most abundant, the grower should see that colonies of the beneficial insects are at hand. Cowpeas may be used as a means of multiplying ladybirds of the six or seven commonest species in Hawaii, if the plantings are not in the neighborhood of valuable trees or plants which are also subject to attacks of aphids.

Jack beans do not come to maturity so rapidly as cowpeas and may be used where it is desired to keep the ground covered longer. They are also less subject to the attacks of aphids.

The pigeon pea (*Cajanus indicus*), has proved a valuable leguminous plant, but its growth is so tall and also so woody that it becomes difficult to cover.

A number of other legumes are being tested in plats and some of the more promising of these may be tried under orchard conditions.

WIND-BREAKS FOR ORCHARDS.

A wind-break has been planted about Fields B and C. This consists of a row of *Eucalyptus robusta* on the outside, and a row of Monterey cypress (*Cupressus macrocarpa*) within. The trees in each row are about eight feet apart and the Monterey cypress stand opposite the open space between the Eucalyptus. By these two species, the Eucalyptus running rapidly upwards, and the cypress being of dense growth near the ground, it is expected to provide an effective wind-break.

VEGETABLES AND SMALL FRUITS.

Mr. C. J. Hunn, assistant horticulturist, has under way a number of experiments with vegetables, muskmelons, and the

roselle. A test of quite a large number of varieties of tomatoes is being made with a view to determining, among other things, their varying degrees of resistence to the melon fly. An attempt is being made to grow muskmelons under a cheese-cloth covering to protect them from the melon fly.

A trial is being made of the "Mercedes" type of sweet potato in comparison with a few local varieties. It is this type which is being almost universally found in the Pacific Coast markets, which Hawaii should supply during the spring and early summer months. It may prove best to introduce our own varieties in these markets.

The culture of the roselle has been continued and some tests have been made in drying this fruit. Mr. Hunn submits the following data on the subject:

"A number of queries concerning the advisability of drying the roselle, thus making it less bulky for, and less susceptible to decay during shipment, have come to the attention of the horticultural staff. Accordingly, a number of experiments were undertaken to ascertain the advisability of drying the roselle, dealing almost exclusively with the calyx of the plant, since this is the portion generally used in jam or jelly making.

"Three separate experiments were conducted in drying the roselle, the first two being with the Porto Rican strain, and the third, with the Victor variety. The first lot was picked November 24, 1908—36 weeks from sowing; the second lot, on December 8,—38 weeks from sowing; and the third, on December 8, 1908,—36 weeks from sowing. The first lot was placed out of doors for drying on November 26, 1908, and kept in the open as much as possible, being removed to a dry building at night, and at other times because of the frequent rains which are so prevalent at this time of the year, and which would seriously interfere with the ultimate results of drying. The fruits were placed in shallow slatted flats with cotton cheese cloth spread over the bottom to prevent loss through the slats. When sufficiently sun dried, the flats were stacked in a dry airy exposure to finish curing.

"The results of the drying experiments are as follows:—The portion eliminated before drying equals 32 per cent, leaving 68 per cent, which is the total weight of the calyces to be dried. The calyces in drying shrank to 8.8 per cent of the total

weight of the fresh fruit, or lost, in drying, moisture equal to 7.7 times its weight. Consequently, one pound of the dried calyces is equal to 8.7 pounds of the fresh calyces, or to 12.8 pounds of the fresh fruit.

"If fresh roselle sells at four cents per pound, in order to make an equal profit from the dried calyces, it should sell at about forty-five cents per pound, plus the cost of drying. In drying the roselle such items as severing the calyces and the seed pod by cutting, separating the calyces from the seed pod after cutting, boxes, the moving and the care of the fruit during drying and storage must also be considered. From figures obtained from companies who are interested in the production of jellies and preserves, we ascertain that they are not willing to pay such a price for the dried roselle and offer less than one-half.

"It is apparent that the rational and profitable method of marketing Hawaiian roselle is in the form of jams and jellies, manufactured here, thus avoiding the cost of drying. It is also probable that the fresh fruit will make a finer manufactured product than the dried article."

THE HORTICULTURAL STAFF.

The horticultural staff has been augmented by the appointment in June of Mr. Valentine Holt, a part of whose time is being devoted to horticultural work. Mr. Holt has collected and prepared an exhibit of a large number of fruits and other products now being shown at the Alaskan-Yukon-Pacific Exposition. He has begun work in the selecting and propagation of varieties of papayas with a view of systematic breeding.

MISCELLANEOUS NOTES.

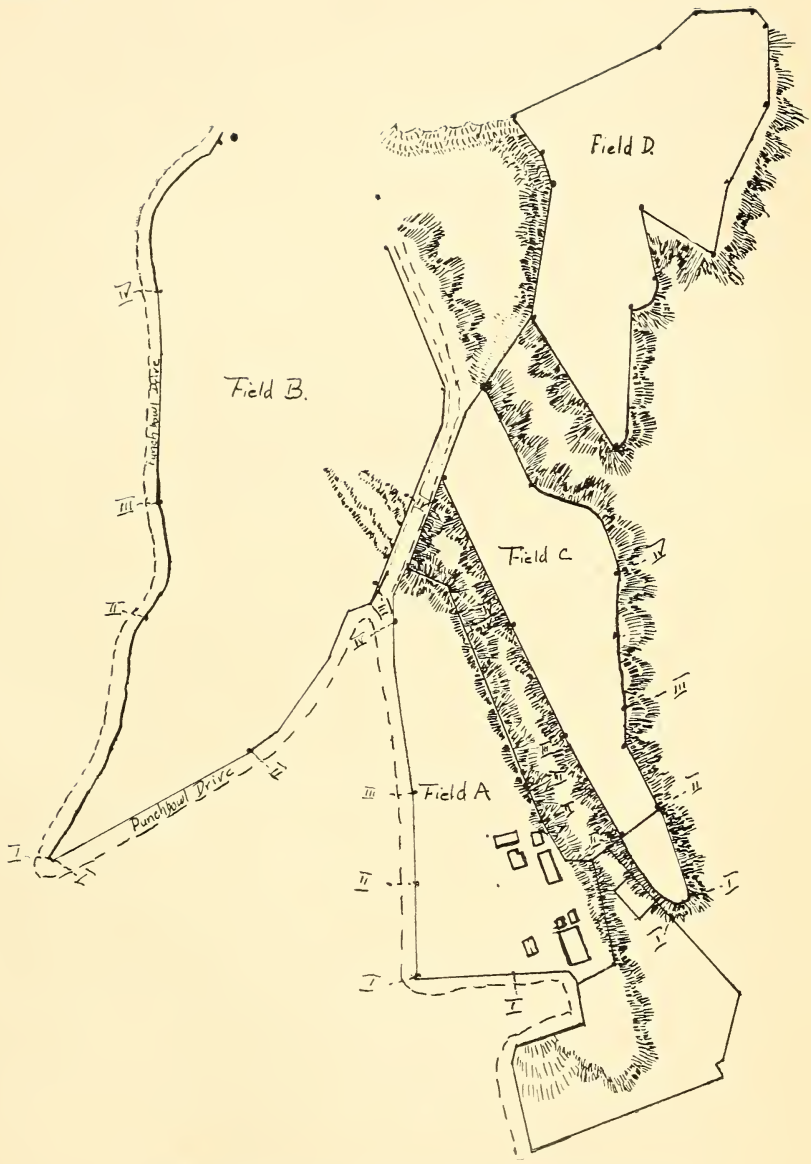
The horticulturist again visited the deciduous orchards planted in recent years at the Parker Ranch on Hawaii and advised in matters of pruning and general care, also noting the progress of the orchards which give every promise of success.

The three varieties of litchi, introduced in June, 1908, have made a good growth during the year. These varieties are No mi chi, Kwai mi and Hak ip.

Carissa arduina, S. P. I. No. 11,734. This South African

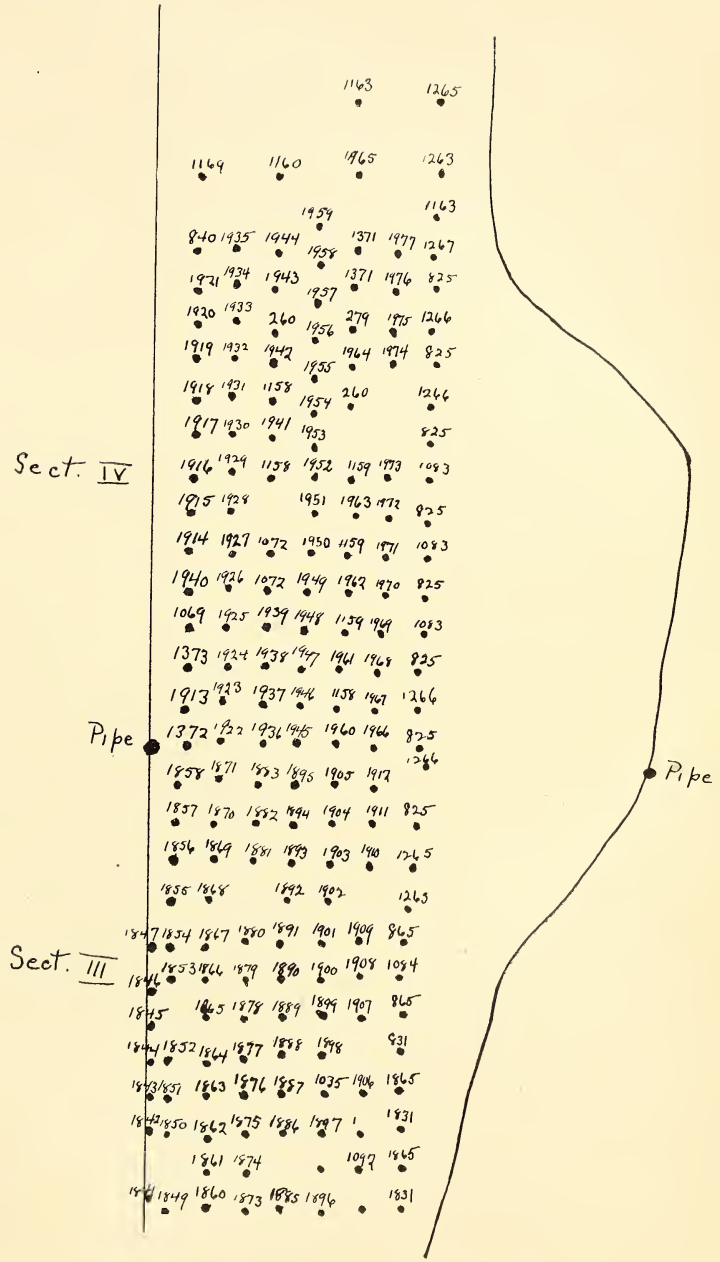
BAHIA NAVEL ORANGE ON COMMON SWEET ORANGE STOCK, 6 MONTHS' GROWTH FROM BUD.

PLATE II.



GENERAL VIEW OF FOUR CULTIVATED FIELDS.

PLATE III.



FIELD C, SHOWING LOCATION OF TREES.

fruit and hedge plant has fruited at the station in the past few months. It has made a strong growth. This, together with its glossy green foliage, its white star-shaped flowers and its bright red fruits, renders it an attractive hedge plant. It is armed with quite heavy thorns. The fruits are edible and have been appreciated by many of those who have tried them at the station. The species is being further propagated.

The Eden pineapple has fruited for the first time at the station. The other hybrid pineapples are now making a good growth but none have produced fruit.

Coleococcus amicarum. Through the kindness of Mr. W. S. Lyon, of Manila, a successful introduction was made of this economic plant. The five plants have been planted out.

Rattan palm, *Calamus* sp. (Dæmonorops). Through Mr. H. P. Wood, Secretary of the Hawaii Promotion Committee, two introductions of seeds of rattan palm have been made from Java. A large percentage of these have germinated and are doing well.

REPORT OF THE CHEMIST

By W. P. Kelley

The work of the chemical department during the past year has been devoted to the following lines of investigation: A study of the pineapple soils of Oahu; an investigation of the fertilization and nutrition of rice; fertilizer experiments with cotton; and miscellaneous.

PINEAPPLE SOILS.

The pineapple soils throughout the islands are, for the most part, located above the cane lands at elevation of from 600 to 1,000 feet. At least two-thirds of the land devoted to this crop is situated on the upland plain between the Koolau and Waianae mountain ranges of Oahu. This section is subjected to extremely variable climatic conditions, especially as regards rainfall. Some months a very heavy precipitation, to the extent of 10 or more inches, followed by a very dry period, produces in the soil wide variations. From the very beginning of this industry it has been the practice to grow pineapples continuously on the same land with little or no rotation of crops; although some of the growers fallow their land one or two years out of every five. In many instances the farmers, on account of the presence of various insects, have been induced to burn or remove from the land every vestige of the old plant before preparing for a new crop; and while it is true that the fruit alone does not make very heavy drafts on the soil, any single crop system, coupled with the burning or removing of plant residues, is an exhaustive one, and one that is likely to produce ill consequences.

Even if the ash of the old plants be left on the soil, thus returning to the land the minerals taken from it in the growth of the previous crop this practice robs the soil of the nitrogen which the previous crop consumed. Not only is the soil in this way robbed of its nitrogen, but any humus, which the organic matter is capable of producing, is also destroyed. The active forces that predominate in these soils at the high temperatures,

which prevail throughout a large part of the year, bring about a rapid oxidation of the organic matter in the soil; and any system that involves removing from this land the organic matter produced thereon without the growing of green-manuring crops or the application of humus-producing manures, leads to bad physical, chemical, and biological conditions in the soil.

Furthermore, these soils contain large amounts of finely divided ferric hydrate, which becomes gelatinous when wet, and has a high water-holding power.[1] During the periods of heavy rainfall the soil becomes saturated with water, and in consequence of its fine state of division, large percentage of ferric hydrate, etc., the water is held tenaciously. Organic matter, on the other hand, would tend to make the land more porous and thus bring about better drainage.

The growers have observed from the outset that the soils in this section naturally fall into two classifications as regards color,—black and red soils. Influenced by the fact that black soils are almost universally regarded as rich soils, the prospective growers, at the begining of this industry, eagerly sought the soils of dark color. But it has been found subsequently that the red soils are naturally better adapted to pineapples than these black lands. Usually the plants present a peculiar appearance on the black soils, and do not grow as successfully as on the red land. The fruit on the black soil is characterized by a whitish-pink color, lack of flavor and an excess of acidity. The red soils, while producing large yields of excellent fruit at the beginning, yield diminished harvests with each subsequent planting. These practical difficulties have brought about a demand on the station for assistance in the way of analyses of soil samples and for advice in regard to the use and selection of fertilizers.

Recognizing the importance of this crop, and the need of scientific information as regards these soils and their fertiliz ation and management, the station has undertaken an extensive investigation of the questions involved. After some preliminary investigations and a general study of the conditions and practices in the three principal areas of this island, a series of forty fertilizer plat experiments was begun on the red and black soils, respectively, and in each instance, on land that had previously produced two or more crops of pines. The principal objects in

1 Soils, by Hilgard, p. 196.

making these experiments were to determine the fertilizer requirements of pineapples on each of these types of soil; and to ascertain whether or not it is possible, by the use of fertilizers, to maintain the original yields of fruit. On the black soil it was hoped to find some practical means of overcoming the yellow color of the plants. The red soil experiment is located on the land of the Hawaiian Pineapple Company at Wahiawa, and after thorough tillage and good preparation, fertilizers were applied and pineapple plants transplanted on September 8, 1908. The black soil experiment is located on lands of the Wahiawa Consolidated Pineapple Company, the fertilizer being applied and the crop transplanted on September 19.

About eighteen months is required from the time of planting until the first harvest, and therefore, it is too soon to draw final conclusions in regard to the relative officiency of various fertilizers used in the experiments. But without attempting to discuss these in detail, it may be said that certain combinations of fertilizing substances are producing thrift and vigor, whereas others are not proving so effective.

At this time, however, the author wishes to further emphasize the importance of the very best possible drainage for pineapples, especially on the red soils. The fertilizer experiments on the red soil are located on a gentle incline, but unfortunately, the rows on part of this experiment run at right angles to the direction of natural water flow; and although open ditches are maintained every thirteenth row, that is about fifty feet apart, the drainage on this part of the experiment has not been effective. Furthermore, the same combinations of fertilizing substances that are producing good effects on the better drained portion of the experiment, are not producing similiar effects on the more poorly drained portion. Various applications of different fertilizers to this red soil by the growers have often given promise of good harvests, but it frequently develops at some period in the growth of the crop that there is something else lacking in the soil besides available plant food. Often the plants grow satisfactorily some months after planting, especially if this happens to be during a period of comparatively light precipitation, but later it is observed that there are scattering plants, or sometimes spots of considerable size on which the plants are not growing well. These appear to be stunted, often

reddish-yellow in color around the outer edges of the leaves; and upon pulling up such plants, it is found that the roots are dead and the whole underground part of the plant is water-soaked, sometimes fermenting and half rotten. Such conditions seem to be most frequent and make their first appearance following a period of continued rains or a deluge. In several authentic cases, a heavy downpour caused an overflow of ditches, and consequently a flooding of the land, and in the course of a few days the plants on the flooded areas showed just the appearance pointed out above. Even here the water could not stand above the surface because of its rolling topography, but there was brought about such a saturated condition of the soil that, on account of its high water-holding capacity, due to its high percentage of ferric hydrate, and low humus content, aeration was largely shut off; and stagnation ensued, a condition which the pineapple plant will not tolerate.

During the continued dry weather of last fall, the author found that wherever water had flowed over the soil or the soil had been previously saturated, the plants were not thrifty, and in many instances had died. In such places it was almost impossible to force a spade into the soil, so compact and dry had it become. The incorporation of organic matter in this soil will undoubtedly increase its aeration by enlarging the air spaces and would prevent a serious compacting of the soil and bring about a more uniform distribution of soil moisture; thus effectually preventing stagnation during the time of rains and enabling the soil to hold an optimum of water for a much longer period after rains and at the same time greatly lessening the tendency of the soil to become dry and hard during periods of rapid evaporation. An excess of stagnant water also brings about a bad biological condition, and in soils like these, which contain a relatively large percentage of ferrous oxid, a saturated condition contributes to the formation of considerable amounts of ferrous carbonate and ferrous sulphate, bodies which are known to be plant poisons. In addition, nitrification is seriously interfered with, and possibly the solubility of certain minerals is changed.

In connection with the field experiments, a laboratory study of these soils has also been undertaken. A large number of samples of each type of soil has been analyzed, and some extremely interesting and abnormal conditions have been found.

The following table fairly represents the chemical composition of each of these types of soil:

Table showing water-free composision of some pineapple soils.

	RED					
	SOIL	SUBSOIL	SOIL	SUBSOIL	SOIL	SUBSOIL
	Laboratory No. 5	Laboratory No. 6	Laboratory No. 7	Laboratory No. 8	Laboratory No. 13	Laboratory No. 14
Insoluble matter	43.79	38.64	40.89	39.25	46.52	46.37
Potash (K_2O)	.62	.73	.51	.60	.50	.57
Soda (Na_2O)	.20	.30	.21	.32	.31	.13
Lime (CaO)	.46	.46	.51	.66	.32	.31
Magnesia (MgO)	.41	.35	.37	.38	.40	.42
Iron (Fe_2O_3)	26.11	32.54	35.72	33 28	24.37	24.49
Alumina (Al_2O_3)	10.82	10.45	3.58	8 66	9.15	12.02
Manganese (Mn_3O_4)	.27	.19	.22	.06	.33	.35
Phosphoric acid (P_2O_5)	.13	.16	.07	.08	.09	.13
Sulphur (SO_3)	.08	.04	.09	.07	.11	.12
Volatile matter	13.73	14.06	14.22	13.99	15.98	13.17
Total	100.15	100.60	100.22	100.09	100.28	100.13
Nitrogen (N)	.24	.22	.34	.25	.38	.25
Acidity[a]	1960.00		1568.00		392.00	

	BLACK					
	SOIL	SUBSOIL	SOIL	SUBSOIL	SOIL	SUBSOIL
	Laboratory No. 9	Laboratory No. 10	Laboratory No. 11	Laboratory No. 12	Laboratory No. 15	Laboratory No. 16
Insoluble matter	33.45	36.06	39.02	42.60	33.73	34.53
Potash (K_2O)	.83	.74	.78	.81	.99	1.07
Soda (Na_2O)	.40	.42	.36	.44	.21	.38
Lime (CaO)	1.39	.86	.64	.60	.49	.37
Magnesia (MgO)	.54	.43	.41	.39	.52	.41
Iron (Fe_2O_3)	19.65	21.51	18.24	20.52	26.03	26.85
Alumina (Al_2O_3)	15.50	15.74	15.40	16.89	15.82	18.98
Manganese (Mn_3O_4)	9.74	8.76	4.80	3.50	4.01	2.43
Phosphoric acid (P_2O_5)	.21	.16	.36	.13	.35	.21
Sulphur (SO_3)	.16	.09	.23	.05	.17	.05
Volatile matter	17.73	14.45	19.71	13.72	16.68	12.83
Total	100.33	100.31	100.35	100.23	99.85	99.79
Nitrogen (N)	.39	.23	.45	.19	.35	.20
Acidity[a]	neutral		196.00		98.00	

[a]Calculated to pounds CaO per acre foot.

The above table shows that the two types of soil differ materially in but one point, namely, as regards their respect-

ive manganese content. Since determining that the black soil contains such large percentages of manganese, a thorough investigation of the entire pineapple section has resulted in establishing that all the black soils in this section contain relatively large percentages of manganese; and that there is a close correlation between the manganese content of these soils and the general appearance of the pines. It is not deemed necessary at this time to go into a detailed discussion of this work since a preliminary report has already been issued [1] and the investigation is still under way. It may be said, however, that the manganese in this soil is in an extremely soluble form, even more soluble in weak solvents than any, or all, of the other constituents of the soil combined. It appears that the form of manganese is influenced by the growth of pines, in that it is changed into a higher state of oxidation; and furthermore, such change is detrimental to the growth of the plant. Plants grown on manganese soil are found to contain a higher percentage of manganese than those grown on the red soil, and to possess a markedly different oxidizing power as measured by the rate at which water extracts of the plant change the color of alcoholic solution of guaiacum, etc. This investigation is being continued with a view of determining what influence manganese has upon other constituents of the soil, their solubility, etc., its effects on nitrification and the physics of the soil. A detailed study of the absorption of nutrients of the pineapple plant at the various stages of its growth, on both types of soil, is also being undertaken. Soils of similiar somposition are very rare, and it has been deemed wise to make a study of manganese in its relations to plant growth in general, since here we have an opportunity of studying the effects of this element under natural conditions.

RICE INVESTIGATIONS.

For some years this station has been investigating the rice industry in these islands, reports of which work may be found in the Annual Reports for 1907 and 1908; and in these, the importance of this crop and some of its economic phases have been emphasized. Several fertilizer tests have been made and

[1] Hawaii Sta. Press. Bul. No. 23.

the relative practical economy of various fertilizers has been pointed out. In consideration of the importance of this crop, the conditions under which it is grown, and the old established oriental practices of fertilization, which prevail in rice culture here, and that chemical fertilizers are generally applied when the crop is two-thirds grown, it has been deemed wise to devote some time to a study of some of the more fundamental questions regarding the absorption of nutrients by the rice plant, etc. When it is considered that rice is grown in submerged culture, and therefore variations in composition due to variations in available water supply, are eliminated, it is at once apparent that this crop readily lends itself to fertilization investigations.

Accordingly, in January, 1909, in conjunction with the agronomist, this department instituted a series of fertilizer plat experiments on the rice trial grounds of the station. The object of these experiments is not only to determine the efficiency of various fertilizers, as measured by increased yields of paddy and straw, but to determine at what period in the growth of the rice plant the various nutrients are absorbed, and some of their inter-relations and functions. In these investigations samples from the several plats have been taken at different periods in the growth of the plant. These were separated into their botanical parts and a chemical analysis of each is being made. The cultural part of the work is being done by the agronomist. This work is now in progress and will probably not be completed for some months, since it is hoped to duplicate the experiment with a spring and fall crop. Results of scientific interest, have, however, already been obtained, as for instance, the rice from the plats, which receive certain fertilizers, has been found to have a materially different composition, as regards the nitrogen content, from those without fertilizer. The large amount of analytical work, involved in such an investigation, necessarily prolongs the time of completion; but it is hoped that the data may be ready for publication during the present fiscal year.

FERTILIZER EXPERIMENT WITH COTTON, AND MISCELLANEOUS.

The growing interest in cotton, as a new industry in Hawaii, is sufficient justification for an investigation of every agricultural phase of this crop, and with the knowledge of the import-

ance of fertilization of sugar-cane the prospective cotton growers naturally desire information in regard to the fertilization of this crop. Consequently, in February, 1909, a series of fertilizer plats was laid out on each of the two extensive cotton experiments referred to in this report by the agronomist. It is entirely too soon to draw conclusions from these experiments further than to point out that on each of the experiments it is already apparent that the application of phosphates has greatly increased the growth of the plants.

A small amount of miscellaneous analytical work has been done, such as the analysis of an occasional sample of water, fertilizer, soil, etc.; but it is the policy of this department to confine its efforts, as largely as possible, to a few lines of research, and only in so far as it is necessary in the cooperation of other departments, will miscellaneous work be accepted.

REPORT OF THE AGRONOMIST

By F. G. Krauss.

Rice and cotton investigations continue to be the main lines of work of this division. The rice expriments were begun in 1906, and the cotton work in the early spring of 1908. As a part of these investigations, considerable attention has been given to the testing of field crops with a view to developing cultures suitable for rotation with rice and cotton, and if possible, adapting some of the crops to green manuring. It is recognized that the permanent conservation and upbuilding of our soils is as important as to increase immediate production, and a rational system of crop rotation, together with practical schemes for green manuring are important practices looking to that end. Constant effort is being made to encourage cooperative field experiments with planters, and the past year has seen greater strides in this direction than ever before.

RICE EXPERIMENTS.

The work with rice consists of testing new varieties and the development of pure strains of the best types; experiments to determine the best methods of culture; and fertilizer experiments, together with the testing of crops suitable for rotation or substitution.

The problems affecting the artificial fertilization of the rice crop continue to receive much attention and the results of the work have already aided growers materially in increasing their yields. However, it is recognized that to be of greatest permanent value, work of a more fundamental nature is necessary. Accordingly, in January, the chemist and agronomist planned a series of experiments looking to that end. The cultural end of the investigation has been undertaken by the writer and the chemical work by the chemist.

CO-OPERATIVE FERTILIZER EXPERIMENTS.

Based on the results obtained in a previous experiment,[1] the Palama Rice Plantation on Oahu, consisting of approximately 100 acres, which had not previously used chemical fertilizers, undertook in the spring of this year, under the station's direction, the use of some eighteen tons of a high-grade complete fertilizer of the following composition:

6 per cent nitrogen (3 per cent organic, as fish guano, 3 per cent as sulphate of ammonia).

9 per cent phosphoric acid (4 per cent as water-soluble, 5 per cent as reverted).

10 per cent potash as sulphate of potash. The net cost of the fertilizer was $870.00, or $8.70 per acre. To this should be added transportation and cost of application, which would bring up the cost to approximately $10.00 per acre.

A careful survey of the entire plantation, in company with the proprietor, during April and May indicated that the general fertilization was very effective on all the lands except those near the sea. On May 1st, when the crop was well headed out, the total yield of paddy was estimated at 180 tons as against 131 tons for the previous spring crop.

On May 20, a few days before the beginning of the harvest, a visit was made to the plantation preparatory to making the test weighings. The first field inspected showed the work of a destructive army worm (*Leucania unipuncta*), the full extent of the damage becoming more and more apparent as the inspection progressed. The aid of the station entomologist was called in, and it was soon found that the scourge was prevailing over a wide extent of the rice territory, both on Oahu and Kauai. The damage had been done quickly and was over almost before any one was aware of the pest. This attack of an insect pest on rice was absolutely without precedent in the Hawaii industry. A full report upon the pest will be found in the report of the entomologist.

The total ultimate yield of the crop was 104½ tons of paddy, the smallest crop ever recorded for this plantation, and this, under conditions otherwise the most promising in its history. Some idea of the destructiveness of the caterpillar may

[1] Cooperative Experiments, Hawaii Sta. Rpt., 1908.

be obtained from the fact that one field, consisting of twelve acres, yielded only 11,015 pounds of paddy against 35,000 pounds, harvested the previous season. This was one of the best fields and the first patch to be attacked.

Within the above area a fertilizer experiment, covering 2½ acres, was under way at the time of destruction, so that no more reliable data could be obtained from it than from the general fertilization.

Below are given the yields of the spring and fall crops of the Palama Rice Plantation during the past five years, which may serve to give some insight into the production end of the industry under favorable general conditions and careful management.

YIELDS OF PADDY (STANDARD HAWAIIAN RICE), FROM A 100 ACRE PLANTATION FAVORABLY LOCATED AND CAREFULLY MANAGED.

Year	*Spring Crop.* *Pounds.*	*Fall Crop.* *Pounds.*
1905	335,708	417,680
1906	262,335	353,469
1907	346,434	359,093
1908	256,300	370,168
1909 [1]	209,366	.....

TESTING AND DEVELOPING NEW VARIETIES OF RICE.

Since the beginning of the rice investigations in 1906, the testing and developing of old and new rice varieties has formed an important part of the work of this division. Up to the present time 166 varieties have been tested in comparison with each other, and as to their adaptability for spring or fall culture. The more promising varieties have been grown for from two to six generations. During the past year, as heretofore, the agronomist personally selected a large number of individual rice panicles from among the growing crops of the leading plantations for breeding purposes. The principal growers were also invited to make selections according to their own ideal

[1] Low yield due to unprecedented destruction by army worm.

type. These were further gone over in the laboratory and the best selections propagated with a view to establishing pure strains.

Rice No. 19 (S. P. I. No. 12508) introduced in the fall of 1907, is now believed to be firmly established. Its bad mixture with other types, due to careless harvesting, has been remedied by the propagation of 10,000 seedlings individually during the past fall. The seedlings were set 10 by 10 inches apart and carefully rogued. The yield from a fifth of an acre was 704 pounds pure seed. The entire amount has been distributed among growers in lots of 50 to 100 pounds, sufficient to plant 2½ to 5 acres, if the seed is carefully conserved. It is hoped that fully 50 acres will be planted for the fall crop of 1909.

The difficulty in milling this rice economically, appears to have been overcome by one of the Chinese millers who reports that by thoroughly drying the paddy, setting the millstones far apart, and running them rather more slowly than is the usual practice, he has avoided the high percentage of breakage hitherto experienced. A very satisfactory sample was turned out during the past season and one grower marketed 100 bags at a satisfactory price.

As in the past considerable upland rice seed has been distributed in the hope that this grain would find favor as a cured fodder for horses. No extensive planting has as yet been reported. In a cooperative experiment at the Kunia lands, on Oahu, where the rainfall is very light, a small planting of the two most promising varieties, Nos. 65 and 68, has given promise of being well suited for culture on large areas now devoted to pasture. If the present high price of imported hay continues, there can be but little doubt that the growing of this crop will prove profitable.

COTTON EXPERIMENTS.

These experiments were begun in the spring of 1908 and were briefly reported upon in the annual report for that year. In March of the present year the experimental data to date were reported in Press Bulletin No. 24, entitled "Preliminary Report on Cotton Experiments."

In January of the presence year a collection of thirty varieties and selections of cotton, representing four more or less

distinct types, were planted for comparative test of yield, quality of lint and habits of growth. Considerable attention is being given to the selection of superior individual specimens, with a view to obtaining desirable mother plants from which to breed pure strains. The importance of the new methods devised for the propagation of cottons, i. e., by cuttings or budding, whereby all the qualities of a given individual plant may be perpetuated indefinitely, becomes more and more apparent as the work progresses. A brief review of methods and results will be found below. Pruning experiments, as applied to plants entering their second season of growth, are likewise under way and will be reported upon more fully at the end of the present harvest.

It may be said at this time, that the Sea Island types respond best to low pruing, i. e., when a mere stump, three to six inches in length, is left . Pruning to tall canes, 15 to 30 inches long, resulted in considerable "die back," the basal shoots almost invariably exceeding the growth from terminal buds. A further advantage in low pruning, which should not be lost sight of, is the fact that the entire removal of the old wood, with its adhering trash, destroys possible insect infestation, which might cause trouble with the new crop. In fact, this phase of growing cotton as a perennial is the most objectionable that has as yet been advanced. In the case of the Caravonica types of cotton, cutting back from one to three fourths of the previous season's growth, appears to give the best results. Being of exceedingly rank growth, too severe pruning causes excessive wood growth at the expense of fruit, and furthermore, such rank growth is extremely brittle. This causes bad splintering in heavy winds. When it is remembered that the Caravonica cottons give their lowest yields during the first year after planting, while the Sea Island apparently give their greatest, or at least optimum yields the first season, some good reasons for the practices outlined become apparent. In the case of the upland cottons, low pruning insured a larger percentage of plants being carried over into the next season than high pruning, but when the plant survived pruning to spurs, similar to the methods adopted by the California grape growers, such plants greatly outyielded the low pruned. However, since only a small number of specimens were available for the pruning experiment, it is

possible that the heavy fruiting plants were naturally more vigorous to begin with. Plate IV illustrates the different systems of pruning described above.

Attention has already been called to the more vigorous growth of the Caravonica cottons over other varieties thus far grown. To this characteristic is laid its late fruiting, and as frequently happens, its shyness to bear fruit,—the two objections that have been advanced against this variety. In digging up a number of plants, it was found that they possessed exceptionally prominent tap-roots, and also strong lateral root systems compared with other varieties. In one striking case, and several lesser ones, it was found that transplanting both hastened and made more profuse the subsequent fruiting.

Growing Cotton from Cuttings.

Plate V illustrates the total cuttings made from a single first season plant, which, in this instance, produced 36 soft-wood, or tip cuttings; and 31 hard-wood, or butt cuttings. The former averaged about eight inches in length, and the latter, twelve inches. It is frequently possible to obtain a hundred or more cuttings from a single Caravonica plant.

The general character of the cuttings is shown in the lower illustration of the plate.

Plate VI illustrates the relative growth of good average Caravonica cuttings. The growth, while not equal to that obtained from seed propagation, is quite satisfactory and likely to be improved as the method is perfected. The plant shown in figure 2, began producing "squares" when less than five months old, which is considerably earlier than seedlings bear; but this cannot be said to be desirable if the ultimate yield is affected, which seems probable.

Budding Cotton.

So far as the writer is able to ascertain, the credit for the first practical demonstration of budding, as applied to the cotton plant, is due Mr. E. C. Smith of Pearl City who, with Mr. E. W. Jordan, are pioneers in the culture of Caravonica cotton. In the fall of 1908, Mr. Smith successfully budded one Caravonica into the stock of another cotton of the same variety.

Six buds were inserted in a ten-months-old tree in November and the illustrations in Plate VII show the plant during the following July. The small figures, 1-6, in figures 2 and 3, show the points of budding. Figure 1 shows the tree before pruning, and figure 3, after the tree was pruned. Up to the time of pruning, when the harvest was practically over, this plant bore 90 mature bolls, producing 15 ounces of seed cotton. Figure 4 illustrates the prunings from which the cuttings illustrated in Plate V were made.

The method used was that commonly termed "shield-budding." The method is simple, rapid and effective, so that its application in field culture is eminently practicable.

Grafting has not yet been attempted and seems to offer no particular advantages, except, perhaps, in the case of old trees, such as are now growing on the station grounds. In this case the cleft-graft would seem the best suited.

General Cultural Notes.

While the cotton experiments are now only in their second year, several important general principles appear to be fairly established as essential factors in the culture of cotton in Hawaii, as based on personal observations and experiment.

Soils and Locations.—Deep, well drained, silty loam soils, on the leeward side of Oahu, and from sea level up to 750 feet elevation, appear to be well suited to the culture of cottons generally, without the aid of irrigation, in seasons of normal rainfall, from 20 to 30 inches per annum.

The dry, broken coral lands, skirting Oahu from Honolulu to Sisal, would also appear well suited to cotton, the E. C. Smith experimental patch of Caravonica cottons being a fine example of possibilities in this region.

The sandy low lands and lower slopes of a large area in the Koolau district of Oahu would seem well suited to Sea Island cotton, judging from samples received from that locality.

A twenty-five acre field of Caravonica cotton located at Makaweli, Kauai, gives great promise in the possibilities of cotton growing in that region without the aid of irrigation.

With the exception of sisal, and possibly pineapples, cotton would appear to be as drougth resistant as any crop now grown

in Hawaii; and it is believed that the crop can be grown successfully over a wide area without irrigation.

Tillage.—The importance of deep and thorough tillage has been well demonstrated during the present summer, as well as last year. A fine example of what deep plowing and constant surface cultivation will accomplish, is demonstrated on the Kunia lands, where with only 24 inches of rainfall during the 12 months preceding June 30, a perfect growth has been maintained up to the present time, and the crop promises a large yield. The same is true of the Makaweli experiment. Twenty-five acres are involved in each of these experiments. At the trial grounds, in a dry, gravelly soil, ample moisture has been maintianed to bring a large crop to maturity by thorough surface tillage, preceded by a deep plowing, preparatory to planting. At the station grounds, where cultivation was curtailed on account of interference of the unpruned plants entering their second year's growth, the plants have suffered for the want of moisture.

Varieties.

No question is more often asked than the suitability of different varieties. The question is a hard one to answer at this time. From a cultural standpoint, it may be said in general, that the Caravonica type is the most drought resistant when once established. In well prepared land it sends its prominent tap-root down deeply into the soil. On the thin coral soils, and the compacted substrata at the station grounds, this variety shows physiological qualities that appear to make it less subject to drought than the Sea Island types. As a perennial plant, in localities with long rainless summers, there can be no doubt as to its adaptability. Sea Island cotton will make a good crop with a very moderate amount of moisture, but requires intensive tillage. Dry weather hastens maturity, but excessive moisture produces rankness of growth. It is believed that the low lands, bordering the sea, are best adapted to this variety. The best samples and largest proportionate yield were obtained in Haula, and it is believed that the windward district of Oahu is generally adapted to Sea Island, while the leeward district is better adapted to the Caravonica and upland types.

Sufficient experimental data are not yet at hand to speak

authoritatively concerning the Egyptian cottons. This type is now being grown at Kunia, the Waipahu uplands and at the station trial grounds. In all these places the plants have thriven remarkably well. It has the general habit of the Sea Island type, but is a much ranker grower, the wood being very brittle in consequence, as is also characteristic of the Caravonicas. It matures intermediate between Sea Island and Caravonica, and thus far promises to out-yield all other types as an annual. Owing to its natural rank growth, it is believed that this variety is unsuited to wet localities in this warm climate.

The following varieties of cotton are now under test: *Sea Island type*—Seabrook, one strain of Georgia Sea Island; one strain of Florida Sea Island; five station selections of Sea Island. *Egyptian*—four strains of Mit Afifi, one strain of Ashmouni. *Upland*—Roger Big Boll, Triumph, Sunflower, Southern Hope, Parker, Chinese, Peterkin, Duke Long Staple; *Caravonica*—"Wool" [1], Caravonica "Silk," Caravonica Kidney.[2]

The above will be reported upon in detail at end of the harvest.

Two wild native Gossypiums (*G. tomentosum*), a low spreading shrub, 4 to 6 feet high, bearing yellow flowers and a short dark brown lint; and *G. drynarioides,* an arborescent type, bearing large, red Hibiscus-like flowers, and yielding a very dense dark brown lint, similar to the preceding), are being propagated with a view to using them as a basis for breeding work; it is believed some striking results may be obtained from crossing these varieties with commercial forms of cotton. The drought resistant qualities, and dark colored lints of these types is what especially commends them for the work in hand.

Time of Planting and Distances to Plant.

Season and location determine the time to plant. For warm, well drained soils, any time after January 1 and up to the first of March, is recommended regardless of variety, unless the season for harvest, whether for weather or labor conditions, must be considered. In cold, wet localities, planting had best be delayed till March or April.

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1 In their second year of growth.
2 In their fourth year of growth.

Past experience would indicate that the smaller types of cotton, such as Sea Island and upland, should be planted 2 by 4 feet apart in dry locations, and 2½ by 5 feet apart in moist locations. For the Caravonica cottons, twice the above distances are recommended, and for Egyptian, an intermediate spacing. If to be grown as a perennial crop, every alternate plant in the row should be removed the second or third year. It is strongly urged that only one plant be left in a hill.

Improving a Strain.

As Hawaii must always depend upon the quality of her cotton product, rather than bulk, it becomes important that only the highest quality of fiber be maintained. To do this successfully, the planter must early acquaint himself with the qualities that constitute a superior type and work constantly for that ideal.

Should cotton be grown successfully as a perennial in Hawaii, it should be practicable in time, after having found the exceptional individual plant, to work over by budding an entire plantation to this type.

Two extensive cooperative experiments with cotton on a field scale, were begun in the early part of the year and will be reported upon in a later publication.

MISCELLANEOUS EXPERIMENTS.

The Chinese and Japanese matting sedges, (*Cyperus tegetformis* and *Juncus effusus*), which have been under test during the past two years, are holding their own, and a large stock of plants are available for distribution. Of the three plantings made by parties under the station's suggestion, the larger planting, covering about one and one-half acres, has not proved a success owing to the drying out of the pond to an extent never before known. Subsequently, the pond became flooded and the reeds took a new lease on life.

The two other plantings, each one-half acre in extent, are thriving and represent extreme conditions; the one, on submerged upland marsh, overflowed by fresh spring water; the other, a tide-water marsh too salt for any other culture.

During the year a comparative test was made of some fifty fodder and green-manuring plants, including alfalfa, cowpeas,

peanuts, soy beans, velvet beans and numerous other legumes; also corn, dry-land rices, wheat, oats and some perennial grasses. Numerous selections were made of the choicest individual plants, and a large amount of seed distributed.

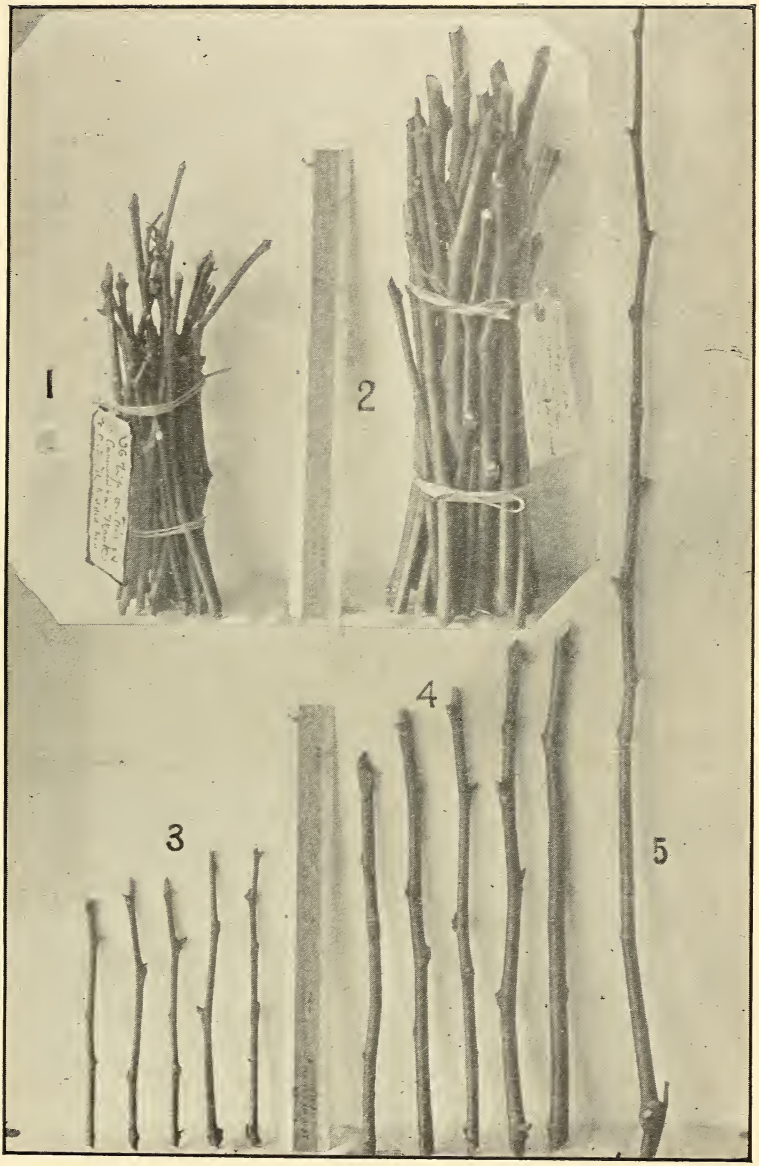
This department in common with other departments of the station, prepared both a federal and territorial exhibit for the Alaska-Yukon-Pacific Exposition. The specimens collected were all agronomic and consisted of 128 items for the federal and about an equal number but larger samples for the territorial exhibit.

Acknowledgement is due the station staff for much valuable assistance rendered this division.

THREE YEAR OLD PRUNED CARAVONICA COTTONS

1. Tall Pruned. 2. Low pruned. 3. Intermediate.

PLATE V.



COTTON CUTTINGS

1, 3, Tip or soft wood cuttings. 2, 4, Butt or hard wood cuttings.

5, Dormant wood, suitable for making cuttings, or cion for budding or grafting.

PLATE VI

FIG. 1.

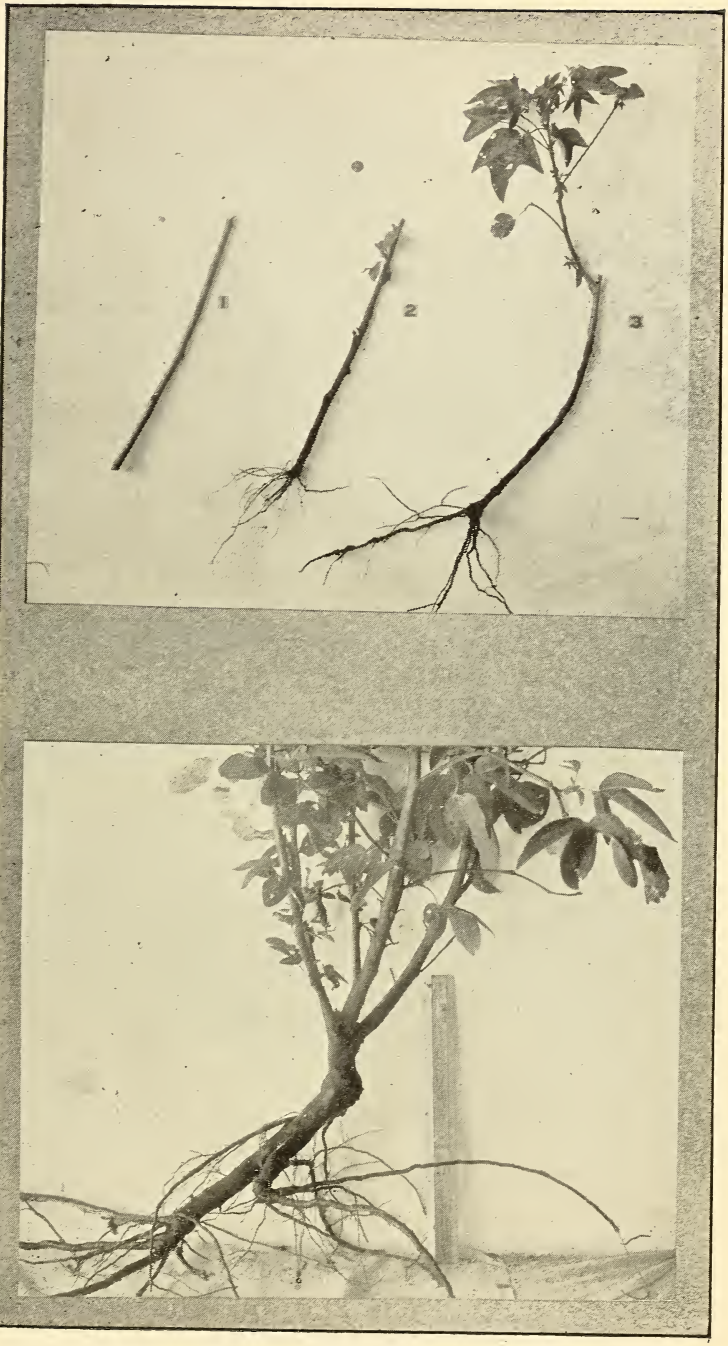


FIG 2.

CARAVONICA COTTON GROWN FROM CUTTINGS.

FIG. 1

FIG. 3

FIG. 2

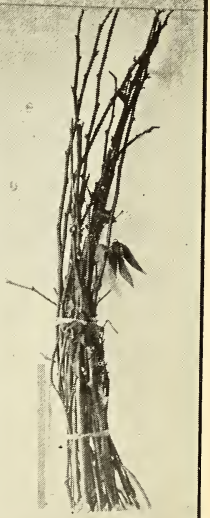


FIG. 4